River Test, Long Parish

NRA

National Rivers Authority

Guardians of
the Water Environment

ENVIRONMENTAL PROTECTION
SCIENCE GROUP

NATIONAL RIVERS AUTHORITY
SOUTHERN REGION

MARINE BASELINE SURVEY 1990-92 I. NUTRIENTS

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SUMMARY

The Southern Region Marine Baseline Survey was initiated in 1990 to determine concentrations of nutrients, metals and organo-chlorine pesticides in coastal waters. Twenty-four stations, including four monitored as part of the National Baseline Monitoring Programme, have been monitored four times per annum since December 1990. This report presents results for nutrients over this period.

Concentrations were generally higher in estuaries than in open coast locations, gradients being evident down some estuaries. Concentrations were also generally higher during winter (October-April) than summer (May-September). These observations reflect the importance of riverine sources of nutrients and their uptake through biological processes. The discharge of major rivers in Sussex and to the southern Kent coast does not appear to cause significant local increases in nutrient concentrations at open coast locations.

There was little evidence of 'elevated' nutrient concentrations, excessive algal blooms or oxygen depletion. Increased monitoring effort in estuaries may be required to enable more rigorous determination of 'sensitivity' in terms of the European Waste Water Directive.

1. INTRODUCTION

Surveys of coastal waters carried out by the NRA Southern Region, and previously by Southern Water, have been designed, primarily, to determine concentrations of sanitary parameters, compliance with environmental quality standards of persistent compounds, or to meet the requirements of EC Directives. With the exception of surveys of nutrients and metals carried out in Southampton Water and the Solent between 1977 and 1983, and of "Red List" substances, which have been monitored throughout the region since 1989, surveys have rarely been designed to establish environmental concentrations of determinands with sufficient statistical precision to enable temporal trends to be determined.

The Southern Region Marine Baseline Survey was initiated in 1990 to determine the concentrations of nutrients, metals and organo-chlorine pesticides in coastal waters to assess the success of pollution control measures. The programme was organised so as to fulfil obligations arising from the NRA National Baseline Monitoring Programme, and to include sites previously monitored for the Joint Monitoring Programme of the Oslo and Paris Commissions. Data from the survey will also be required for the designation of "sensitive waters" in respect of the EC Waste Water Directive.

The nutrients data presented in this report are from the period December 1990 to October 1992. Additional data collected as part of our commitment to the National Baseline Programme will be included in later reports.

2. METHODS

Twenty-one sampling stations (Table 1 & Map 1), remote from the immediate influence of anthropogenic inputs, were selected. In addition, three sites in Southampton Water and the Eastern Solent (Stations A, B & C), which had been previously monitored as part of the Joint Monitoring Programme, were included. Stations 6 (Selsey Bill), A, B and C meet the NRA Southern Region's monitoring requirements under the National Baseline Monitoring Programme.

Samples were collected at approximately 3 month intervals, with a minimum of two months between surveys. On each occasion, samples were taken from a depth of 0.5 m on both the outward and return journeys. Water column profiles of temperature, salinity and dissolved oxygen concentrations were recorded at each location.

Samples were collected using "blue book methods" where possible. Samples for nutrients analysis were filtered using 1.2 µm pore GF/C filters and immediately frozen in order to minimise deterioration prior to analysis.

A list of determinands and matrices is presented in Table 2. Analyses were carried out at the NRA Welsh Region laboratory, Llanelli using NAMAS accredited methodologies.

3. RESULTS & DISCUSSION

Results are presented in Tables 3-10 and Figures 1-9. The latter present "winter" and "summer" mean values (± standard errors). Statistical analysis of normalised data has not been undertaken; lack of overlap of standard error range should not, therefore, be taken to imply statistical significance.

3.1 Dissolved oxygen (Table 3 Figure 1).

Percent saturation of dissolved oxygen was generally higher during the summer period (101±1%) than during the winter (96±1%), possibly reflecting increased phytoplankton activity during the summer. For instance, elevated summer saturations in Rye Bay appear to have been associated with high chlorophyll A concentrations. However, this relationship did not hold for other locations, especially estuaries. In these locations, the biochemical oxygen demand of river discharges and mobilised silt might compensate for photosynthetic production. There was some evidence of saturation gradients down estuaries such as Southampton Water, especially during the winter period, reflecting increased run-off from rivers.

Although saturation was generally lower in estuaries compared with open coast locations, there was no evidence of significant deoxygenation; at no time did saturation values fall below 70%. It should be noted, however, that results presented here are sub-surface values. Lower saturation values would be expected closer to the substratum.

3.2 Ammonia (NH_3-N) (Table 4 & Figure 2).

Concentrations ranged from a minimum of < 3 $\mu g l^{-1}$ at a number of open coast locations during the winter period, to a maximum of 400 $\mu g l^{-1}$ at Station A, Dock Head, again recorded during the winter period. Concentrations were generally higher in the winter (33.6±3.3 $\mu g l^{-1}$) than in the summer (28.1±2.5 $\mu g l^{-1}$) reflecting riverine inputs.

Relatively high winter concentrations at Stations 1 & 2, Hengistbury Head and The Needles, might be due to the proximity of the discharge from the River Avon, local sewage discharges or the westward dispersion of water from Southampton Water through the Solent. High concentrations recorded at Selsey Bill, especially during the summer period, could result from the eastwards dispersion of water from sewage sludge dumping grounds adjacent to the Nab Tower.

A concentration gradient was evident down Southampton Water, indicating the importance of riverine inputs at the head of the estuary. Concentrations in the Thames estuary were, in contrast, low, and only marginally higher than open coast concentrations.

3.3 Nitrate (NO_3-N) (Table 5 & Figure 3).
Concentrations ranged from a minimum of < 1 μgl^{-1} at a number of open coast locations, to a maximum of 2000 μgl^{-1} at Station A, Dockhead. Both concentrations were recorded during the summer. However, concentrations were generally higher in the winter (191±1 μgl^{-1}) than in the summer (101±22 μgl^{-1}). This reflects higher river flows and reduced biological activity, and hence uptake, during the winter period. As above, maximum concentrations occurred in estuaries (Southampton Water/Solent/Thames, Stations A, B, C, 20 & 21), concentration gradients reflecting the importance of riverine sources.

There was no evidence of particular localised coastal effects due to the major rivers (Arun, Adur, Ouse & Rother) discharging along the south coast. Winter concentrations were comparable to those reported by the Oslo & Paris Commissions (> 210 μgl^{-1}) for the English Channel (Anon., 1992). However, elevated concentrations at Station 1, Hengistbury Head could again be explained by the proximity of the River Avon.

3.4 Nitrite (NO_2-N) (Table 6 & Figure 4).
The data for NO_2-N were very variable, with large standard errors, particularly over the winter period. Concentrations were generally higher during the winter period (5.6±0.4 μgl^{-1}) than the summer (2.5±0.2 μgl^{-1}). Particularly high concentrations during the winter period at stations 8-10, Worthing-Newhaven, may indicate a high level of microbial activity along this stretch of coastline.

3.5 Orthophosphate (PO_4-P) (Table 7 & Figure 5).
The highest concentrations were largely restricted to estuarine locations during the winter period. However, elevated concentrations were also recorded during the winter at Station 2, The Needles. Again, this could be due to the influence of local discharges, or to westward dispersal from Southampton Water. The mean winter and summer concentrations across all stations were 29.6 ± 1.6 μgl^{-1} and 15.3 ± 1.5 μgl^{-1} respectively, reflecting increased biological activity, and hence uptake, during the summer period. Again, winter concentrations were comparable to values (> 26 μgl^{-1}) published by the Oslo & Paris Commissions (Anon., 1992).

3.6 Silica (SiO_2-Si) (Table 8 & Figure 6).
Maximum concentrations (up to 1170 μgl^{-1}) were recorded in estuarine locations during the winter period, and minimum concentrations (min. < 1.7 μgl^{-1}) in open-coast locations, again during the winter period. The mean winter and summer concentrations were 145 ± 8 μgl^{-1} and 50 ± 5 μgl^{-1} respectively, reflecting uptake by planktonic diatoms during the summer period.

3.7 Suspended solids (105°C) (Table 9 & Figure 7) and Chlorophyll (Chl A) (Table 10 + Figures 8 & 9).

In contrast to other determinands, the highest concentrations of suspended solids were recorded during the summer period, with especially high values being recorded at Stations 9 & 10 (max. 149 mgl^{-1}), 13 (max. 129 mgl^{-1}) and 20 (max. 127 mgl^{-1}). The standard errors associated with the mean concentrations were, however, very large. Overall, concentrations were higher during the winter (12.8±0.9 mgl^{-1}) than the summer (8.4±2.0 mgl^{-1})

High concentrations of suspended solids did not correspond consistently with maximum chlorophyll concentrations. Maximum chlorophyll concentrations (up to 14.2 μgl^{-1}) occurred in estuarine locations (Southampton Water/Thames) with smaller peaks at Stations 4-6 and 12-14.

The 'high' chlorophyll concentrations recorded, are, nevertheless, relatively low and do not indicate significant phytoplankton populations. This would tend to contradict arguments made above concerning the reduction in concentration of nutrients due to biological activity during the summer period. However, phytoplankton populations are very dynamic in both time and space, and more intensive surveys would be required to monitor these changes.

4 Conclusions.

Nutrient concentrations were generally high in estuaries compared with open coast locations, concentration gradients being evident down estuaries. Concentrations were also generally higher during the winter period than during the summer. These observations reflect the importance of riverine sources of nutrients and their uptake through biological processes.

While the discharge of major Sussex rivers did not appear to cause significant local increases in nutrient concentration at open coast locations, there was some evidence of elevated concentrations of certain parameters in Poole/Christchurch Bay.

Where there is evidence of nutrient enrichment, it may be necessary to increase sampling frequency, especially over the winter period, to determine concentrations with greater precision.

References

Anon. 1992 Nutrients in the Convention area. Oslo & Paris Commissions.

Table 1

Coastal Waters Baseline Monitoring points.

Station	Site	Latitude	Longitude
1	Hengistbury Head	50° 42.00 N	01° 45.00 W
2	The Needles	50° 38.20 N	01° 39.00 W
3	St Catherines Point	50° 33.00 N	01° 18.00 W
4	West Princessa Buoy	50° 40.15 N	01° 03.50 W
5	Nab Tower	50° 40.10 N	00° 57.00 W
6	Selsey Bill	50° 40.00 N	00° 50.00 W
7	Middleton-on-Sea	50° 44.70 N	00° 35.07 W
8	Worthing	50° 46.20 N	00° 22.50 W
9	Brighton	50° 47.00 N	00° 10.08 W
10	Newhaven	50° 45.50 N	00° 00.12 E
11	Beachy Head	50° 42.50 N	00° 16.00 E
12	Bexhill	50° 47.00 N	00° 30.00 E
13	Rye Bay	50° 51.00 N	00° 44.00 E
14	Dungeness	50° 53.50 N	01° 00.00 E
15	Sandgate Buoy	51° 02.20 N	01° 11.10 E
16	South Foreland	51° 08.00 N	01° 23.50 E
17	Goodwin Fork Buoy	51° 13.30 N	01° 27.00 E
18	East Brake Buoy	51° 19.50 N	01° 29.00 E
19	East Margate Buoy	51° 27.00 N	01° 25.14 E
20	Shivering Sand Buoy	51° 30.00 N	01° 04.90 E
21	Medway Buoy	51° 28.80 N	00° 53.10 E

National Baseline Monitoring Programme Sites:

A	Dockhead	50° 52.90 N	01° 23.50 W
B	Calshot	50° 49.20 N	01° 18.00 W
C	East Brambles Buoy	50° 47.20 N	01° 13.55 W
(6	Selsey Bill	50° 40.00 N	00° 50.00 W)

Map 1. A map showing the position of sampling stations used for the Marine Baseline Survey.

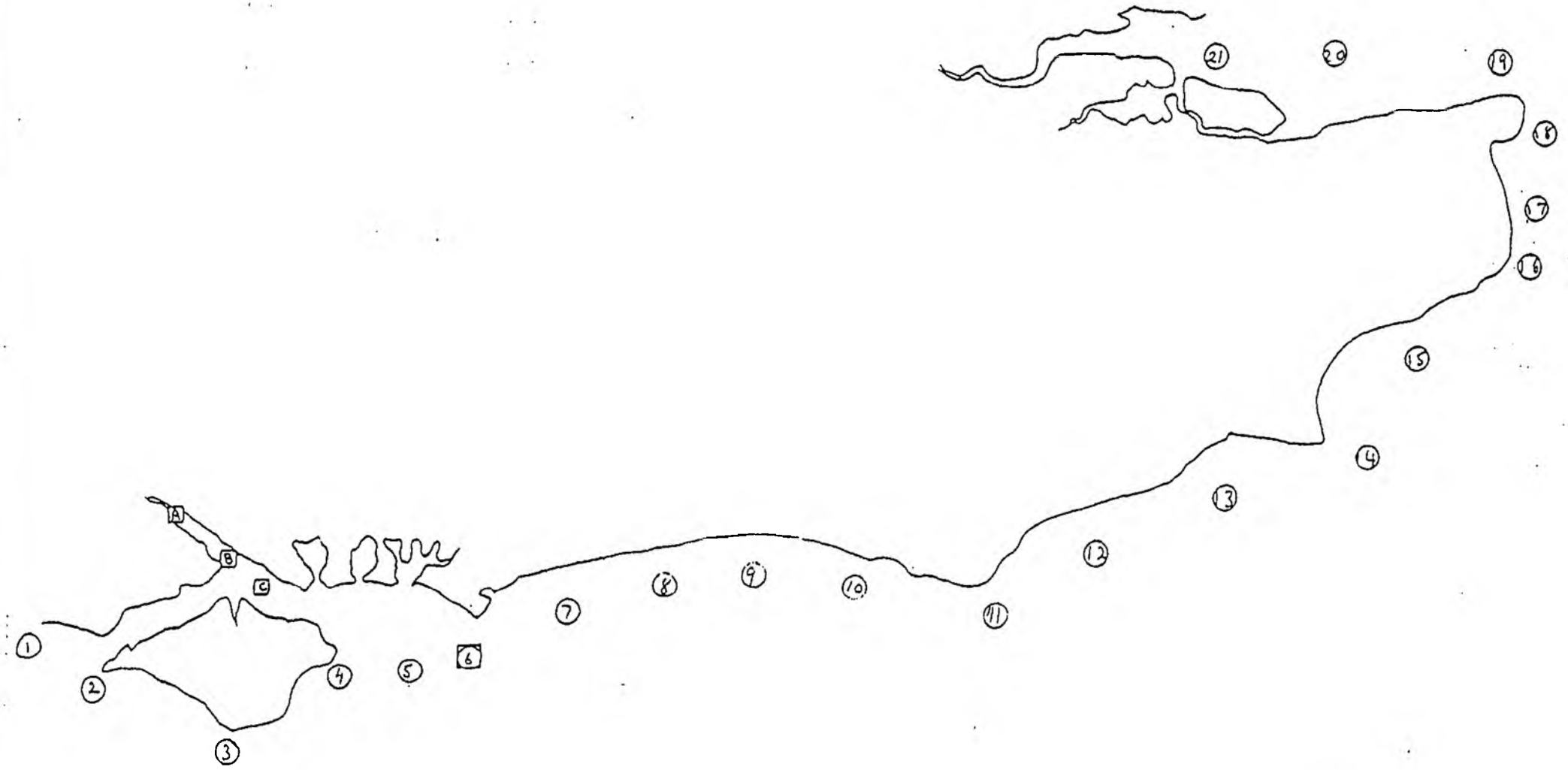

TABLE 2

Coastal Waters Baseline Chemical Determinands and Matrices

Determinands

Routine

= Salinity
= Temperature
= Oxygen
* NH_3-N
* NO_3-N
* NO_2-N
* PO_4-P
* SiO_2
= Suspended solids
Chlorophyll a
+* = Cu
o+* = Pb
o = DDT
o+* = Cd
o+* = Hg
+* = Ni
o+* = Zn
+* = As
+* = Cr
o = HCH (on an individual basis)
o = Dieldrin
o = Aldrin
o = Endrin
o+ = PCB (on an individual basis)

One-off surveys -

Polynuclear aromatics
Polybrominated biphenyls
Dioxins
Triazines = o
Toxophene
Chlordane
Red List substances not already included
HCB
HCBD
PCP
$CHCl_3$
CCl_4

Matrix to be analysed

* filtered water sample
= unfiltered water sample
\+ sediments

NB analysis of sediments must include measurements such as particle size which aid normalization of results. Analyses should be undertaken on the <63µ fraction

o bioaccumulation (organisms consistent with recommendations of bioaccumulation protocol but preferably mollusc for organics and mollusc and seaweed for metals from estuarine sites).

Fig. 1 : Mean Winter and Summer Dissolved Oxygen Concentration
(Winter = Oct-Apr inc.; Summer = May-Sept
1990-1992

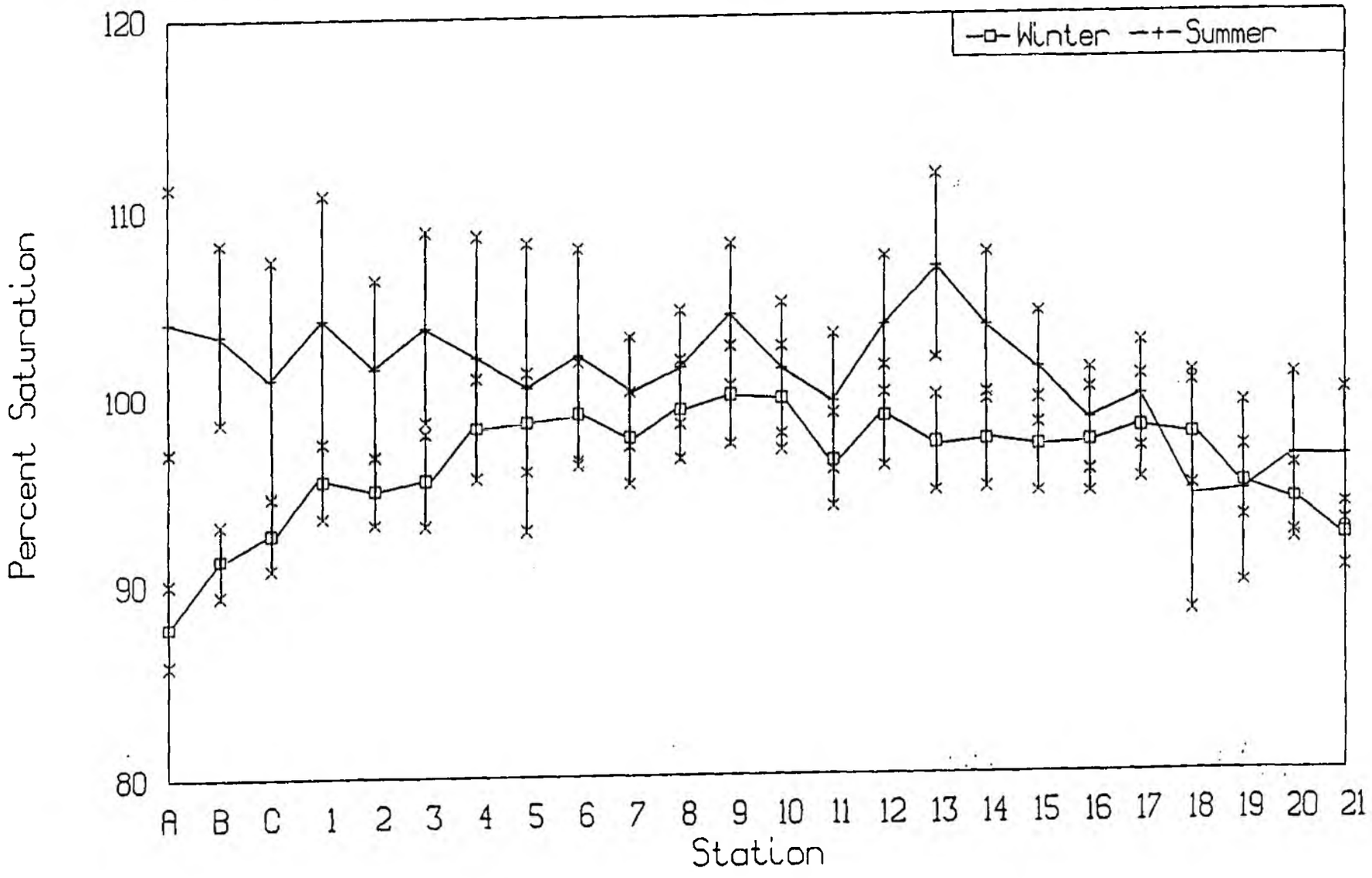

Fig. 2 : Mean Winter and Summer NH3-N Concentrations
(Winter = Oct-Apr inc.; Summer = May-Sept inc.)
1990-1992

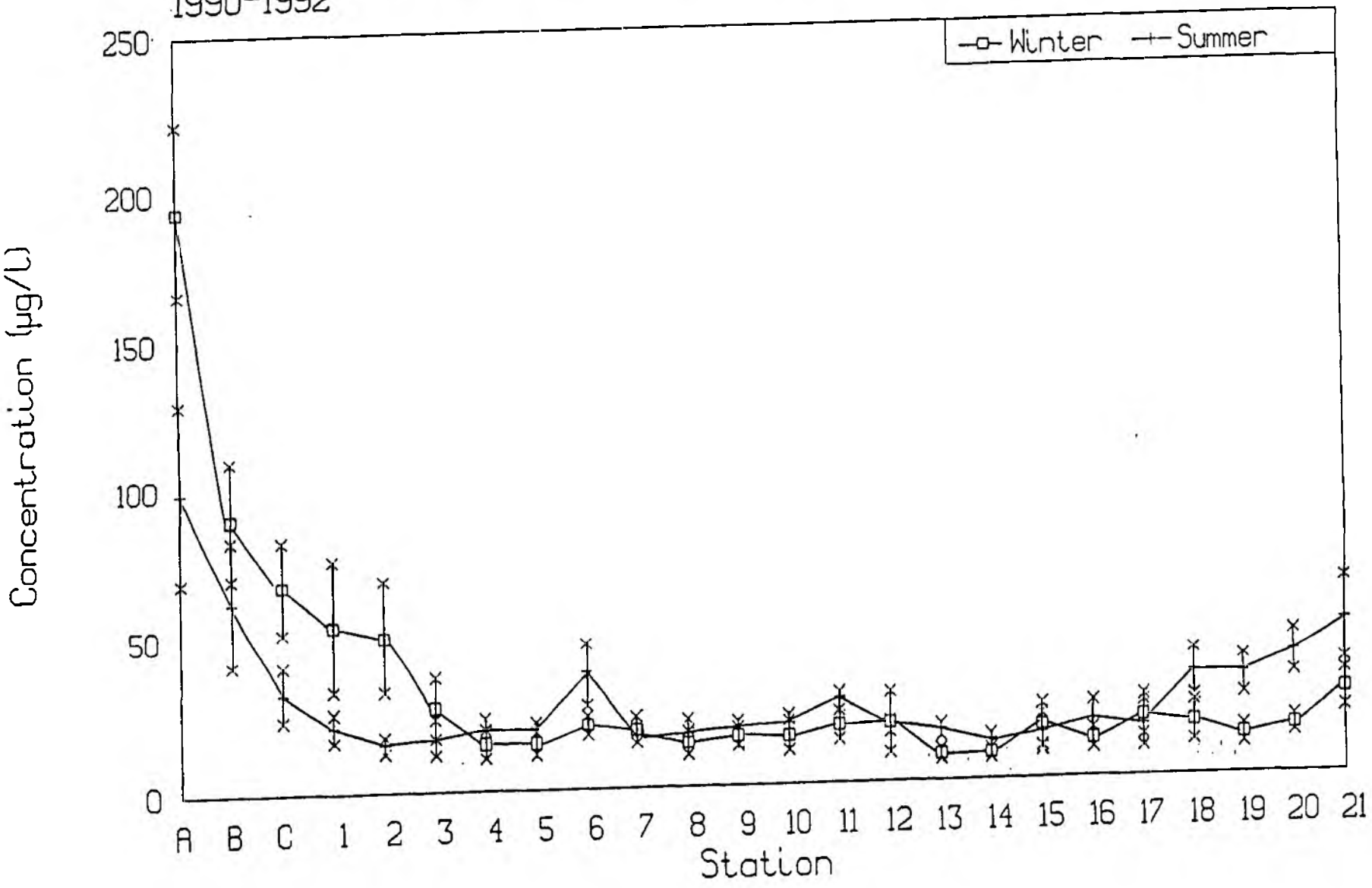

Fig. 3 : Mean Winter and Summer NO3-N concentrations
(Winter - Oct-Apr inc.; Summer - May-Sept inc.)
1990-1992

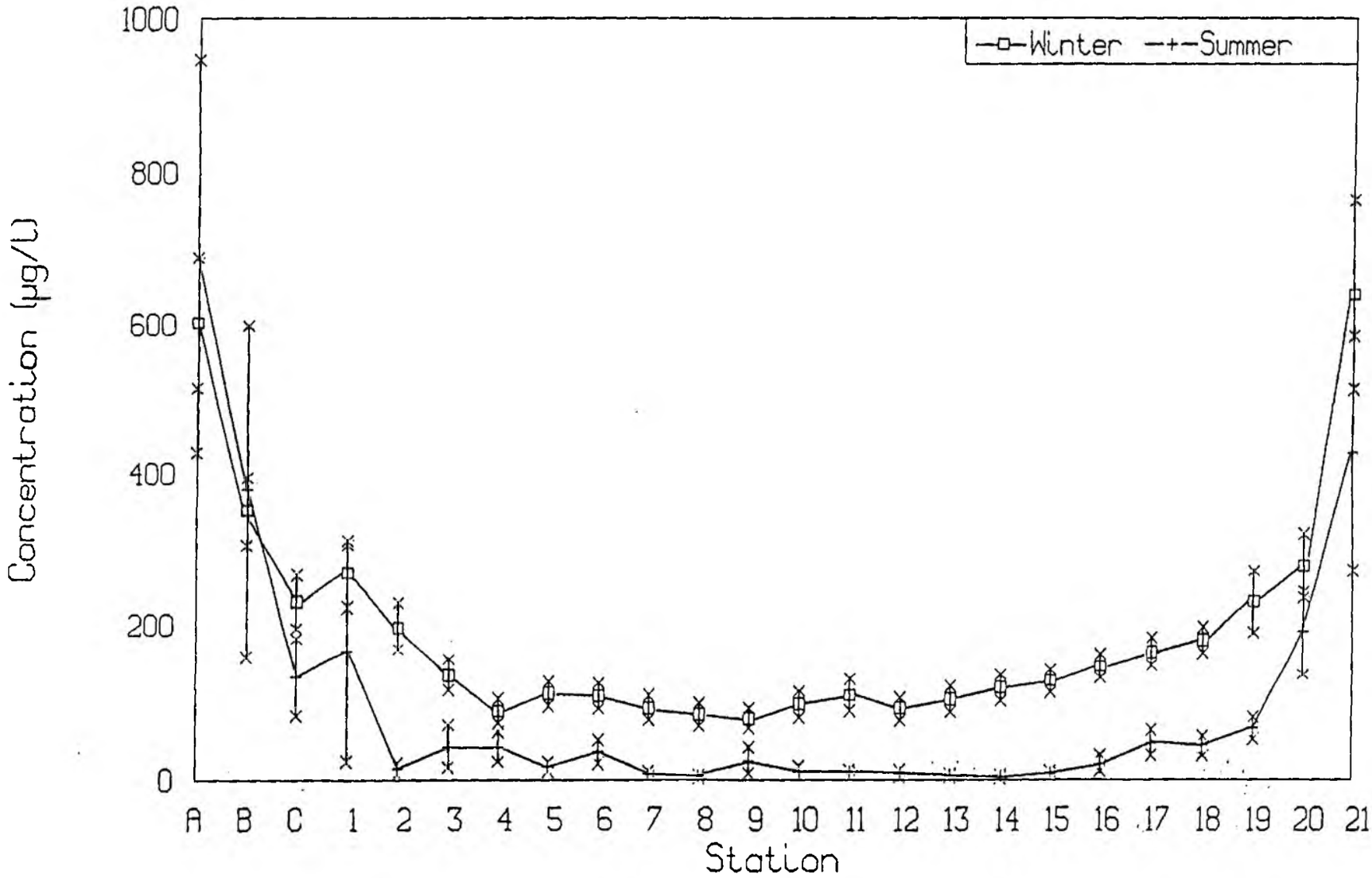

Fig. 4 : Mean Winter and Summer NO2-N Concentrations
(Winter = Oct-Apr inc.; Summer = May-Sept inc.)
1990-1992

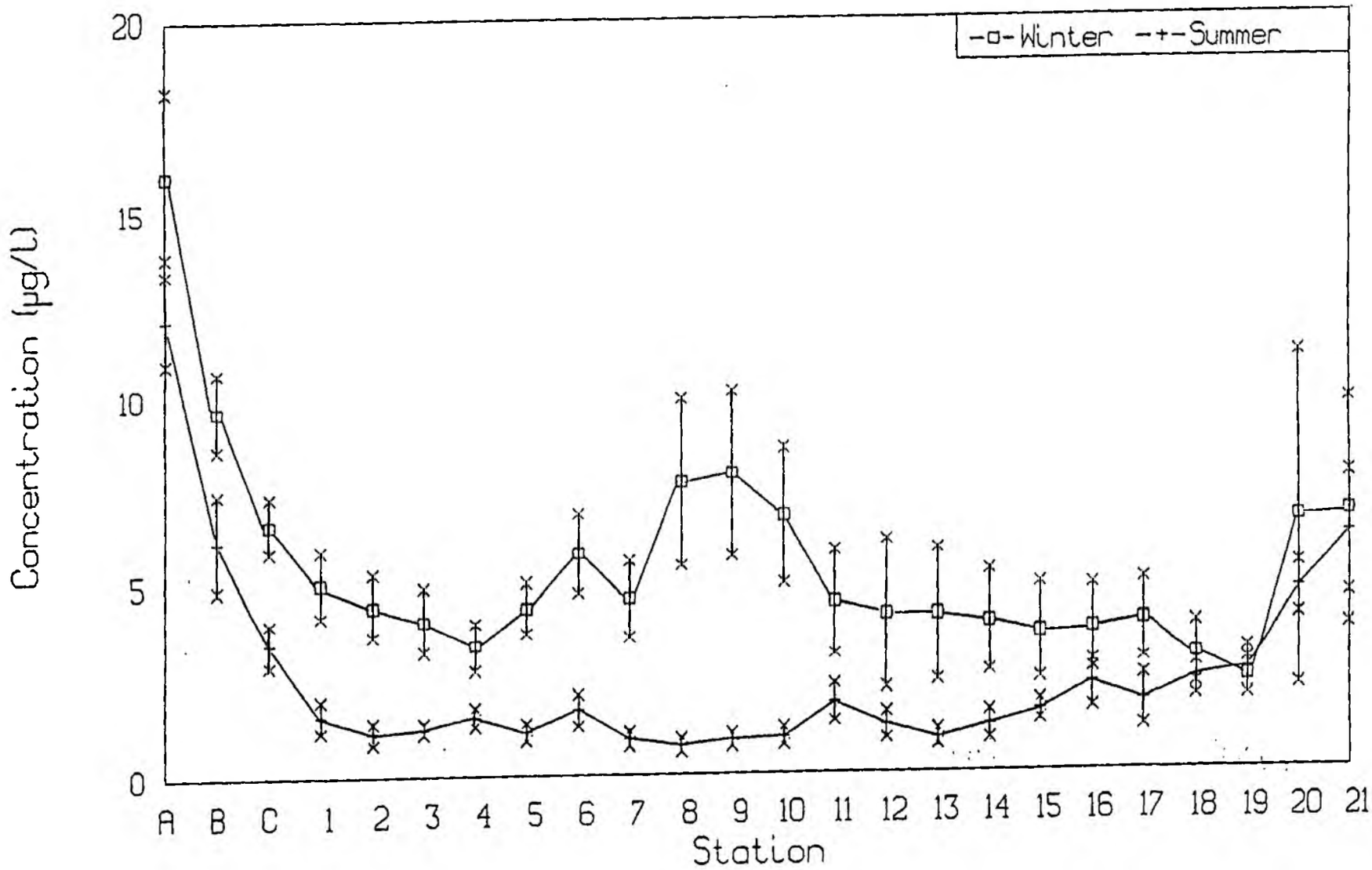

Fig. 5 : Mean Winter and Summer PO4-P Concentrations
(Winter = Oct-Apr inc.; Summer = May-Sept inc.)
1990-1992

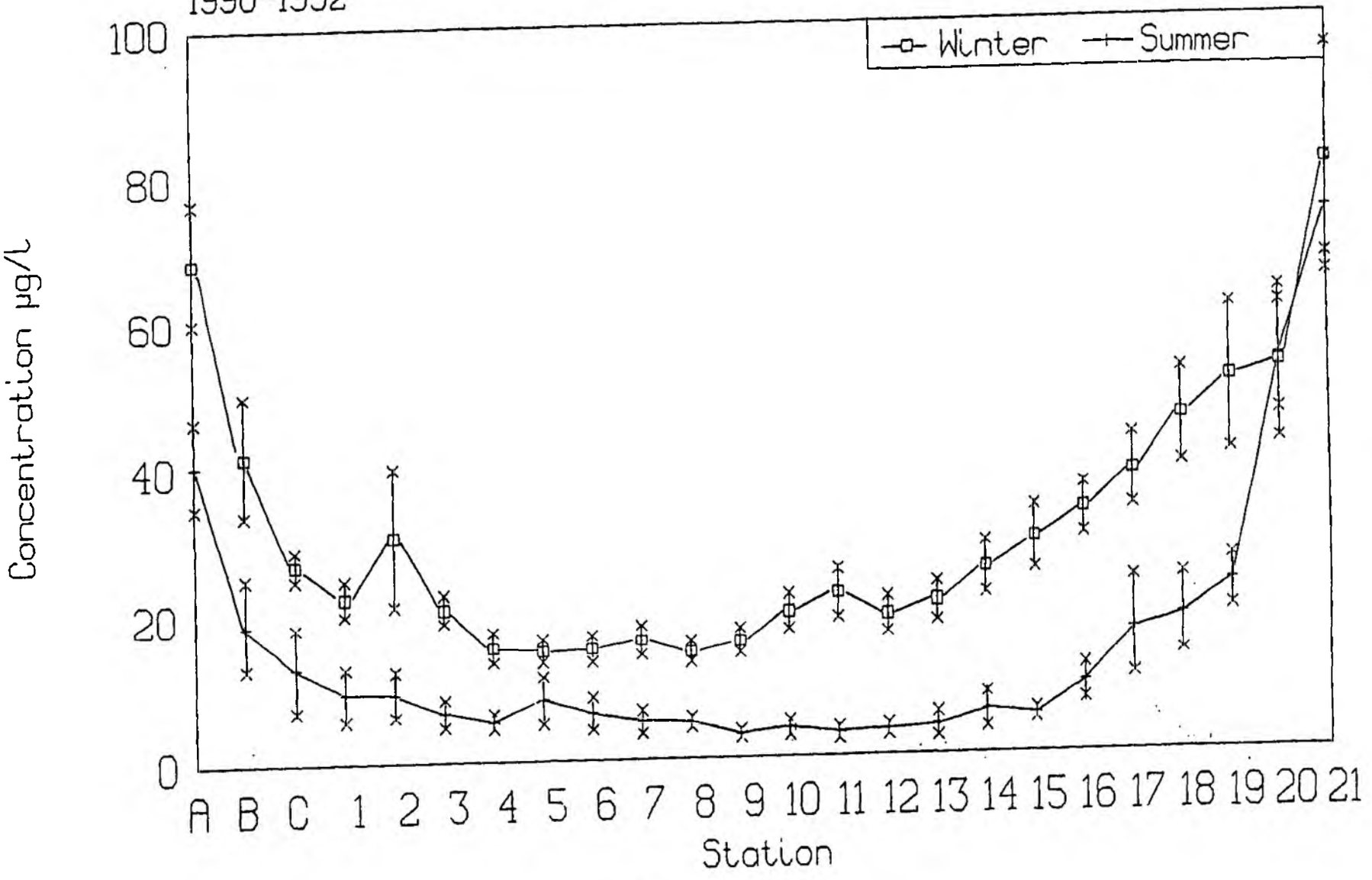

Fig. 6 : Mean Winter and Summer SiO2 Concentrations
(Winter = Oct-Apr inc.; Summer = May-Sept inc.)
1990-1992

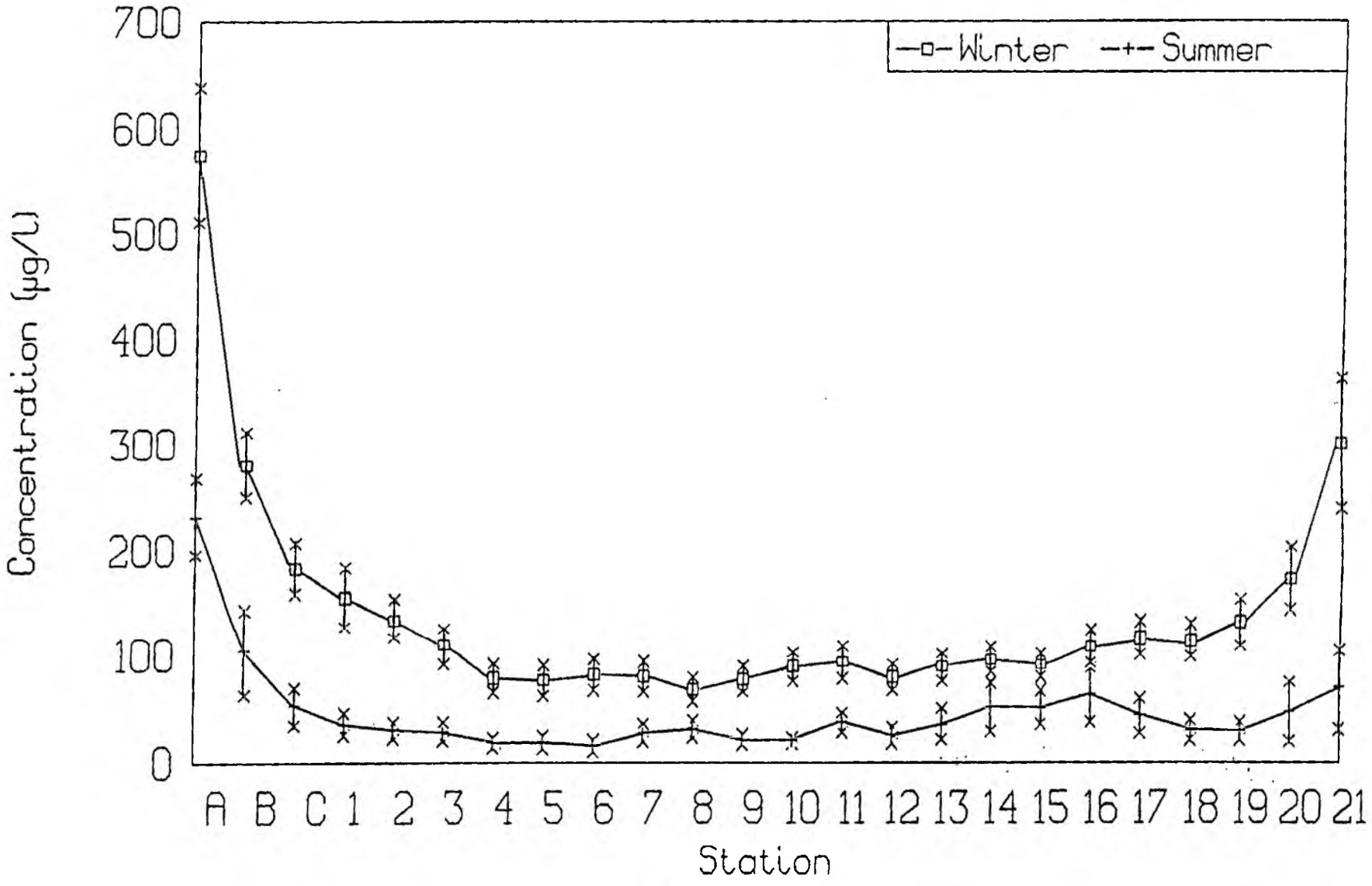

Fig. 7 : Mean Winter and Summer Suspended Solids Concentration
(Winter = Oct-Apr inc.; Summer = May-Sept inc.)
1990-1992

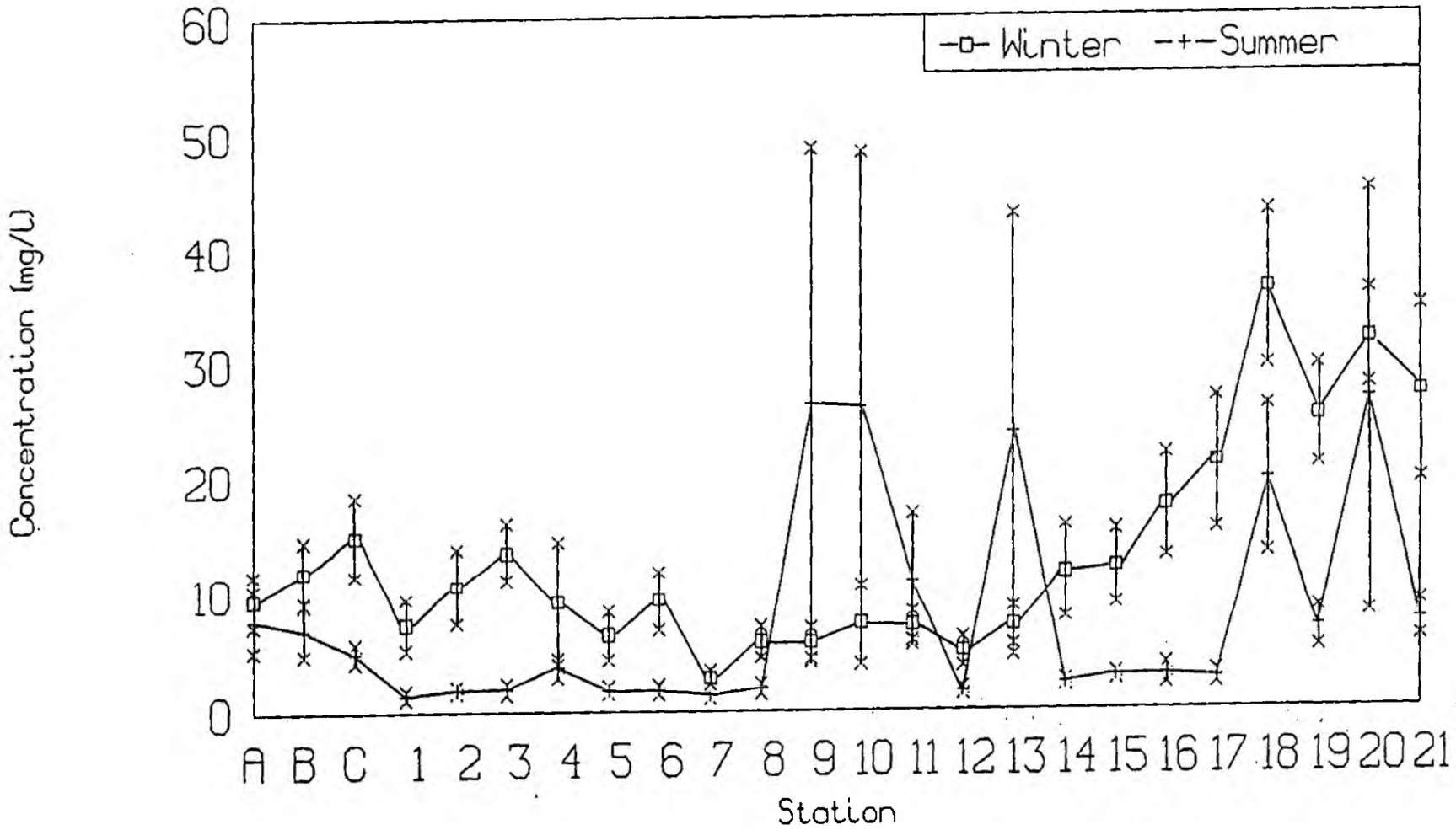

Fig. 8 : Mean Winter and Summer Chlorophyll A Concentrations
(Winter = Oct-Apr inc.; Summer = May-Sept inc.)
1990-1992

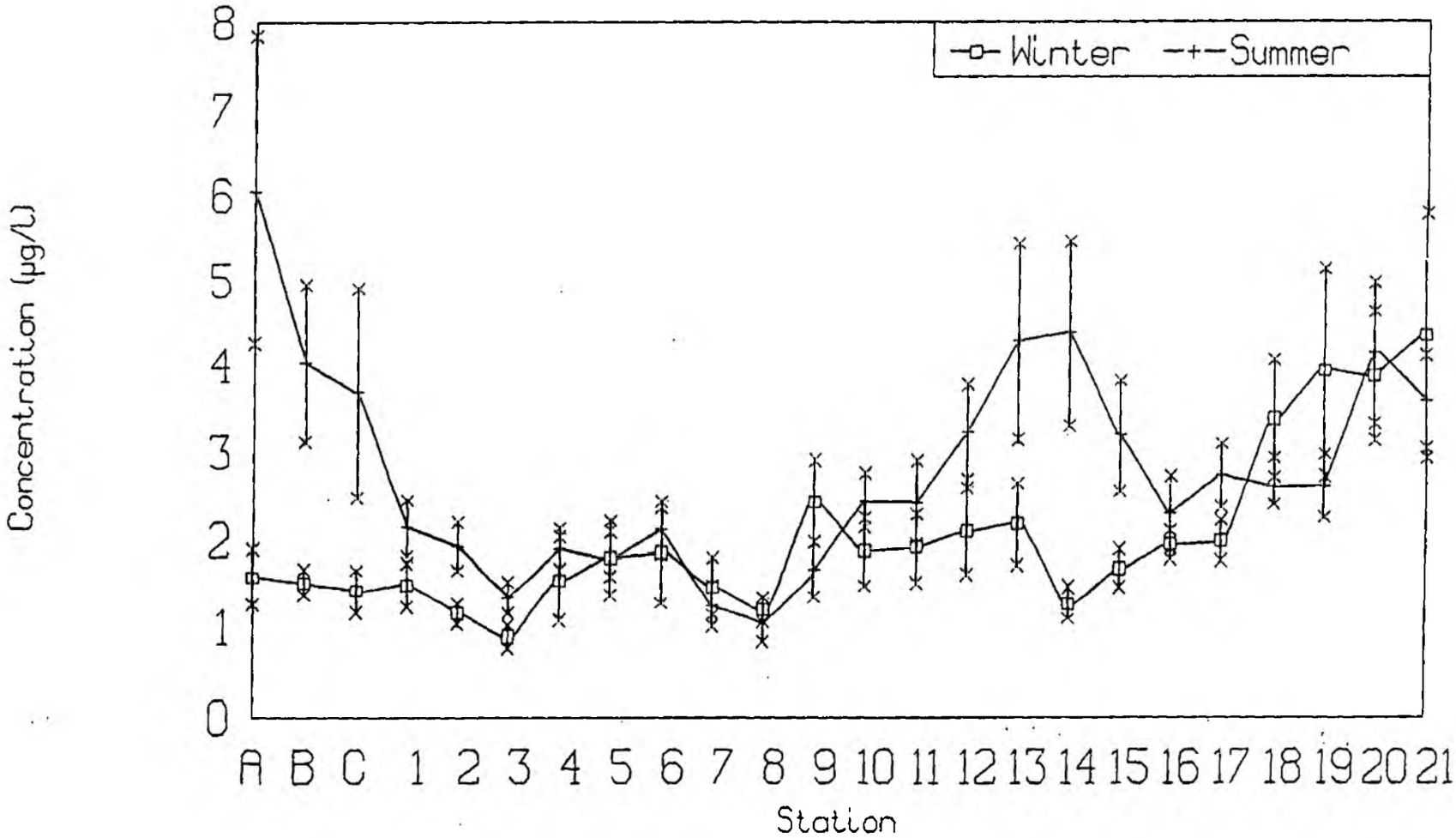

Fig. 9 : Mean Annual Chlorophyll A Concentrations
1990-1992

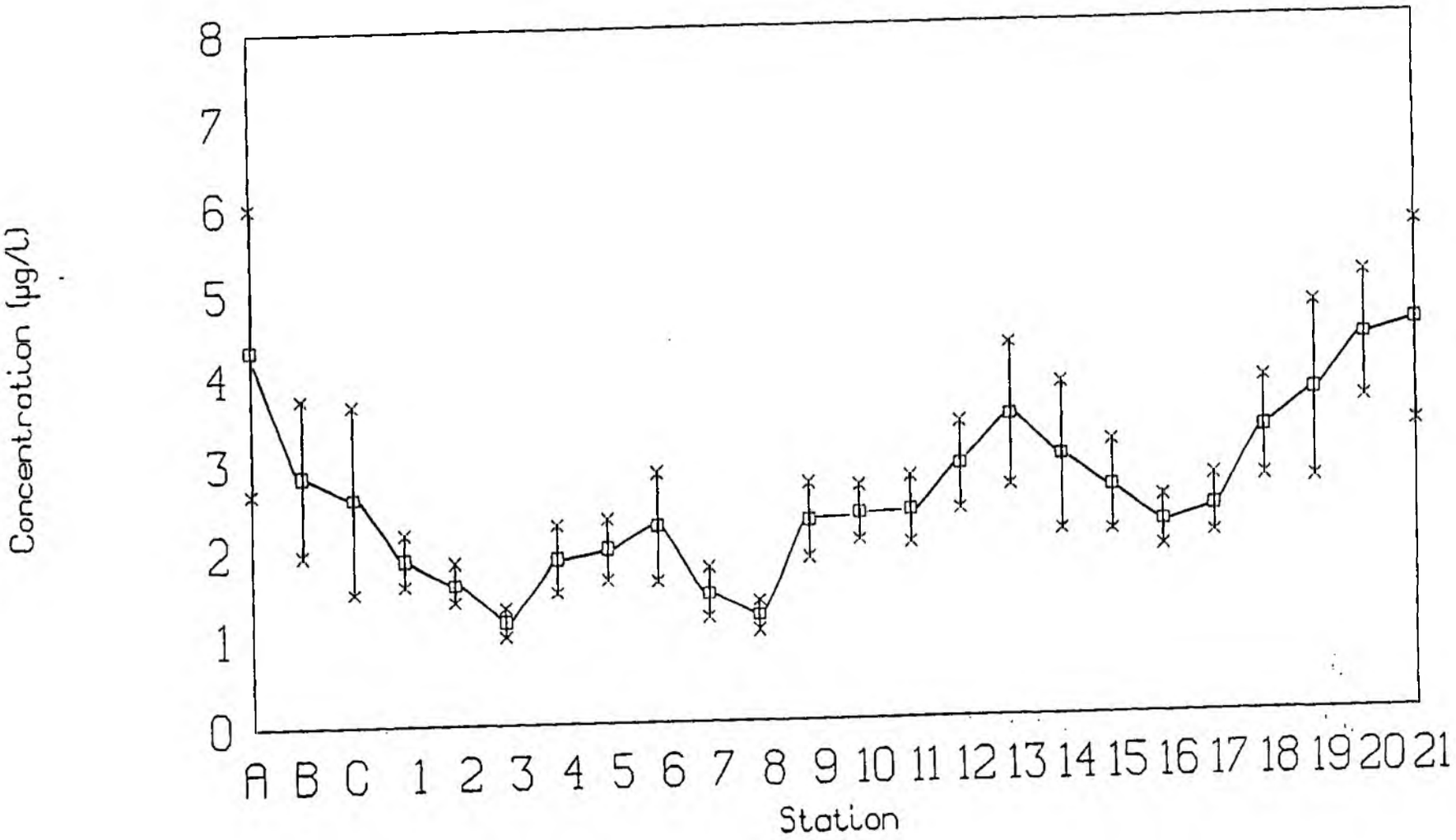

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Table 3 : Percent Saturation dissolved oxygen.

1990 BASE	DECEMBER OUT	DECEMBER RETN
A		
B		
C		
1	106	
2	106	
3	111	
4	112	121
5	110	122
6	113	120
7	104	122
8	109	122
9	106	121
10	107	120
11	104	119
12	104	121
13	104	122
14	106	119
15	112	117
16	115	121
17	121	117
18	121	116
19		
20		
21		

1991 BASE	JANUARY OUT	JANUARY RETN	FEBRUARY	FEBRUARY OUT	FEBRUARY RETN	APRIL OUT	APRIL RETN	JULY OUT	JULY RETN	OCTOBER OUT	OCTOBER RETN
A	96	92	86	91	87	88	96	139	92	77	70
B	100	95	98	91	89	93	96	126	91	82	77
C	100	98	95	95	96	94	95	131	89	82	78
1	107	104		95	96	91	98	130	92	90	82
2	104	103		97	93	91	96	118	91	89	83
3	106	106		97	93	90		116		86	84
4	107	102		97	95	91	102	121	89	85	85
5	107	101		95	96	97	100	124	94	85	84
6	104	102		101	97	107	100	129	95	83	83
7	103	101		98	97	95	98	101	93	85	84
8	108	101		96	99	103	102	99	91	85	84
9	106	102		96	100	112	106	100	96	86	85
10	105	102		93	101	108	115	98	92	85	84
11	102	99		98	92	103	93	97	88	85	81
12	106	100		98	96	106	109	99	92	84	84
13	106	102		93	93	100	100	102	91	83	87
14	107	103		99	94	96	100	99	89	83	82
15	104	100		100	96	96	95	95	91	83	84
16	106	102		98	92	95	95	96	86	86	82
17	107	99		97	94	98	96	93	89	86	85
18	104	100		96	94	98	98	97	88	85	85
19	105	102		90	94	102	102	97	91	85	86
20	103	101		91	94	100	101	96	91	85	85
21	99	98		91	88	97	100	90	88	83	84

Table 3 cont. : Percent Saturation dissolved oxygen.

1992	FEBRUARY		MAY		JUNE		JULY		OCTOBER	
BASE	OUT	RETN	OUT	RETN	OUT	RETN	OUT	RETN	OUT	RETN
A	90	90	97	97			97	103	90	88
B	95	90	101	101			103	99	93	94
C	95	90	99	99			100	88	92	96
1	94	87			99	101		99	95	97
2	96	87			97	106		96	95	95
3	97	86			98	108		93	96	95
4	96	90			103	111		86	97	97
5	99	90			85	113		86	96	99
6	98	89	97	97			105	90	96	95
7	98	90			107	108	102	90	98	95
8	98	90			109	107	108	95	95	96
9	98	90			115	114	108	93	95	98
10	97	92			113	108	105	92	94	94
11	98	87			113	104	103	92	95	94
12	97	90			112	113	110	97	95	95
13	96	90			123	115	112	98	94	95
14	97	90			115	111	109	99	94	95
15	95	91			112	103	103	104	95	94
16	93	92			103	105	100	101	94	92
17	95	92			105	105	104	103	94	92
18	94	89			99	109	108	67	94	94
19	95	92			99	101	107	73	95	94
20	95	87			99	96	115	82	94	94
21	93	88			95	104	110	91	93	93

	Winter October-April					Summer May-September				
BASE	Mean	std	se	High	Low	Mean	std	se	High	Low
A	88	7	2	90	86	104	16	6	111	98
B	91	6	2	93	90	103	11	4	108	99
C	93	6	2	94	91	101	14	6	107	95
1	95	7	2	97	94	104	13	6	110	98
2	95	6	2	97	93	102	10	4	106	97
3	96	8	2	98	93	104	9	4	108	99
4	98	10	3	101	96	102	13	6	108	96
5	99	10	3	101	96	100	15	7	107	94
6	99	10	3	102	96	102	13	5	107	97
7	98	9	2	100	95	100	7	3	103	97
8	99	10	3	102	97	101	7	3	104	99
9	100	10	3	103	97	104	9	4	108	101
10	100	10	3	102	97	101	8	3	105	98
11	96	9	2	99	94	100	8	3	103	96
12	99	10	3	101	96	104	8	3	107	100
13	97	9	2	100	95	107	11	4	111	102
14	97	9	2	100	95	104	9	4	107	100
15	97	9	2	100	95	101	7	3	104	99
16	97	10	3	100	95	99	6	3	101	96
17	98	10	3	101	95	100	6	3	102	97
18	98	10	3	100	95	95	14	6	100	89
19	95	6	2	97	93	95	11	4	99	90
20	94	6	2	96	92	96	10	4	100	92
21	92	5	2	94	91	96	8	3	100	93

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Table 4 : NH_3-N concentrations (μgl^{-1})

1990 BASE	DECEMBER OUT	RETN
A	370.0	
B	109.0	
C	20.0	
1	6.7	
2	21.0	
3	<3.0	
4	<3.0	
5	<3.0	<3.0
6	4.7	25.0
7	13.0	<3.0
8	11.0	<3.0
9	24.0	7.6
10	11.0	17.0
11	<3.0	7.0
12	<3.0	<3.0
13	<3.0	<3.0
14	<3.0	3.2
15	<3.0	<3.0
16	<3.0	<3.0
17	<3.0	<3.0
18	3.7	<3.0
19		
20		
21		

1991 BASE	JANUARY OUT	RETN	FEBRUARY	OUT	RETN	APRIL OUT	RETN	JULY OUT	RETN	OCTOBER OUT	RETN
A	199.0	400.0	302.0	4.1	114.0	137.0	109.0	20.2	54.6	149.0	112.0
B	307.0	90.0	37.0	5.0	8.5	95.4	9.1	14.3	11.2	154.0	75.6
C	185.0	26.0	49.0	8.4	187.0	35.6	9.9	11.8	13.7	79.8	25.1
1	78.0	303.0		6.8	106.0	22.8	7.8	4.5	29.5	53.1	24.0
2	203.0	4.0		5.6	187.0	28.7	13.2	15.7	10.2	68.5	20.2
3	32.0	<3.0		5.1	15.1	11.8		9.4		54.8	21.2
4	16.0	<3.0		5.5	21.3	9.5	16.6	19.5	13.4	62.0	
5	<3.0	<3.0		9.5	10.6	37.8	9.0	15.2	11.4	14.6	21.1
6	19.0	<3.0		6.5	34.8	24.4	13.8	9.3	28.9	41.3	21.8
7	39.0	<3.0		10.4	61.7	12.8	12.7	12.4	12.6		17.6
8	<3.0	<3.0		9.2	55.6	18.5	11.2	14.2	10.9	12.7	17.7
9	15.0	<3.0		15.8	19.6	15.6	9.0	6.3	10.6	13.5	15.4
10	<3.0	8.1		4.6	5.6	14.6	11.2	23.5	10.6	12.9	14.5
11	17.0	<3.0		7.5	54.6	20.8	16.7	18.2	25.8	11.3	13.7
12	<3.0	<3.0		4.0	145.0	10.8	13.5	23.4	9.9	11.5	14.4
13	<3.0	<3.0		5.6	7.5	12.2	8.5	13.1	9.9	10.9	12.6
14	<3.0	<3.0		5.5	8.1	9.9	9.3	14.1	10.6	9.9	22.1
15	<3.0	<3.0		2.9	91.7	15.6	6.5	15.7	12.1	24.5	12.7
16	<3.0	<3.0		10.9	43.3	8.4	30.2	18.7	9.6	8.8	13.1
17	<3.0	<3.0		8.1	83.9	30.8	18.2	9.8	15.5	59.7	20.1
18	5.4	<3.0		17.8	<3.0	14.6	6.4	15.1	17.8	17.7	9.1
19	3.0	<3.0		<3.0	5.7	36.3	13.8	12.0	14.2	17.7	20.1
20	<3.0	<3.0		26.7	23.3	21.5	12.2	12.4	25.7	11.9	8.9
21	30.0	21.0		77.4	9.3	26.6	12.5	12.1	12.4	8.2	9.2

Table 4 cont. : NH_3-N concentrations (μgl^{-1})

1992 BASE	FEBRUARY OUT	FEBRUARY RETN	MAY OUT	MAY RETN	JUNE OUT	JUNE RETN	JULY OUT	JULY RETN	OCTOBER OUT	OCTOBER RETN
A	165.0	193.0	241.0	102.0			133.0	42.0	232.0	233.0
B	88.0	88.0	70.0	151.0			99.0	25.0	71.0	115.0
C	95.0	95.0	22.0	35.0			75.0	33.0	63.0	62.0
1	<4.0	29.0			8.6	22.0	36.0	24.0	27.0	35.0
2	4.0	12.9			8.7	21.0	26.0	9.0	19.0	67.0
3	4.0	8.1			10.5	23.0	40.0	4.0	127.0	39.0
4	8.0	2.0			13.6	23.0	25.0	29.0	8.0	28.0
5	15.0	7.6			18.5	21.0	21.0	29.0	36.0	43.0
6	8.0	8.7	100.0	51.0			20.0	29.0	42.3	33.0
7	<4.0	10.4			12.3	22.0	13.0	23.0	8.0	43.0
8	<4.0	2.0			7.9	28.0	23.0	26.0	19.0	30.0
9	7.0	4.2			13.0	22.0	31.0	20.0	40.0	33.0
10	<4.0	5.2			17.0	22.0	16.0	30.0	41.0	69.0
11	<4.0	16.0			30.5	21.0	33.0	32.0	35.0	52.0
12	4.0	7.0			20.3	16.0	20.0	17.0	13.0	34.0
13	<4.0	10.0			11.8	20.0	18.0	24.0	18.0	25.0
14	5.7	8.0			3.9	12.0	19.0	17.0	14.0	19.0
15	<4.0	8.0			4.3	10.0	45.0	2.0	9.0	56.0
16	5.4	7.0			7.9	10.0	49.0	16.0	23.0	17.0
17	13.0	12.0			3.8	10.0	55.0	5.0	11.0	8.0
18	89.0	13.0			50.0	11.0	60.0	45.0	45.0	14.0
19	9.6	16.0			42.0	34.0	58.0	30.0	22.0	7.0
20	18.0	24.0			57.0	34.0	62.0	45.0	26.0	10.0
21	22.0	25.0			46.0	48.0	98.0	82.0	60.0	16.0

BASE	Winter October-April Mean	std	se	High	Low	Summer May-September Mean	std	se	high	low
A	194.2	103.7	27.7	221.9	166.5	98.8	73.9	30.2	129.0	68.6
B	89.5	73.7	19.7	109.2	69.8	61.8	51.0	20.8	82.6	40.9
C	67.2	55.9	14.9	82.1	52.3	31.8	21.2	8.7	40.4	23.1
1	53.9	77.5	21.5	75.4	32.4	20.8	11.1	4.5	25.3	16.3
2	50.3	65.0	18.0	68.3	32.3	15.1	6.5	2.7	17.8	12.4
3	26.8	34.2	9.9	36.6	16.9	17.4	12.9	5.8	23.2	11.6
4	15.0	16.3	4.7	19.7	10.3	20.6	5.7	2.3	22.9	18.2
5	15.0	13.8	3.7	18.7	11.3	19.4	5.5	2.2	21.6	17.1
6	20.3	13.2	3.5	23.9	16.8	39.7	29.7	12.1	51.8	27.5
7	18.0	17.6	4.9	23.0	13.3	15.9	4.7	1.9	17.8	14.0
8	13.8	14.3	3.8	17.6	10.0	18.3	7.7	3.1	21.5	15.2
9	15.8	10.3	2.8	18.6	13.0	17.2	8.2	3.3	20.5	13.8
10	15.6	17.6	4.7	20.3	10.9	19.9	6.2	2.5	22.4	17.3
11	18.3	16.7	4.5	22.8	13.9	26.8	5.6	2.3	29.0	24.5
12	18.8	36.0	9.6	28.4	9.2	17.8	4.3	1.7	19.5	16.0
13	8.4	6.8	1.8	10.3	6.6	16.1	5.0	2.0	18.2	14.1
14	8.5	6.1	1.6	10.1	6.9	12.8	4.9	2.0	14.8	10.8
15	16.8	25.1	6.7	23.5	10.1	14.9	14.2	5.8	20.7	9.0
16	12.4	11.9	3.2	15.5	9.2	18.5	14.1	5.8	24.3	12.8
17	19.3	23.3	6.2	25.6	13.1	16.5	17.6	7.2	23.7	9.3
18	17.2	22.7	6.1	23.2	11.1	33.2	19.1	7.8	41.0	25.3
19	12.8	9.9	2.9	15.7	10.0	31.7	15.8	6.5	38.2	25.2
20	15.5	8.7	2.5	18.0	13.0	39.4	17.3	7.1	46.4	32.3
21	26.4	20.4	5.9	32.3	20.5	49.8	32.1	13.1	62.9	36.6

Table 5 : NO_3-N concentrations ($\mu g l^{-1}$)

1990 BASE	DECEMBER OUT	RETN
A	16	
B	318	
C	120	
1	158	
2	158	
3	98	
4	82	
5	102	143
6	111	78
7	116	82
8	122	106
9	140	97
10	94	95
11	196	170
12	163	151
13	177	177
14	177	189
15	177	144
16	267	200
17	189	222
18	166	177
19		
20		
21		

1991 BASE	JANUARY OUT	RETN	FEBRUARY	OUT	RETN	APRIL OUT	RETN	JULY OUT	RETN	OCTOBER OUT	RETN
A	468	914	811	1052	1182	929	570	397	297	202	329
B	588	428	309	581	482	624	325	50	19	228	140
C	322	197	306	359	416	193	410	51	16	92	124
1	355	263		368	585	366	328	4	3	127	53
2	336	211		277	334	197	387	8	<2	47	74
3	190	132		208	233	171		16		31	49
4	59	146		163	161	61	89	12	138	23	
5	136	171		172	149	124	126	4	2	18	45
6	170	123		172	220	38	89	4	14	18	131
7	233	137		91	104	34	51	13	3		68
8	114	147		87	194	57	54	5	<2	14	16
9	98	107		94	107	33	58	7	3	13	20
10	90	79		135	158	43	66	7	<2	9	17
11	160	62		127	78	14	65	14	15	8	22
12	59	85		94	83	51	12	9	<2	11	67
13	89	89		119	81	97	88	3	4	<2	9
14	58	82		102	105	116	108	5	4	38	128
15	70	66		87	81	94	180	9	14	137	149
16	99	143		127	110	122	148	18	10	67	145
17	125	187		108	108	123	126	27	13	273	158
18	181	218		323	85	216	154	50	16	138	230
19	232	207		578	120	347	283	90	119	132	296
20	435	303		594	390	200	129	384	360	199	221
21	1143	1373		1196	850	815	42	322	185	243	197

Table 5 cont. : NO_3-N concentrations (μgl^{-1})

1992	FEBRUARY		MAY		JUNE		JULY		OCTOBER	
BASE	OUT	RETN	OUT	RETN	OUT	RETN	OUT	RETN	OUT	RETN
A	519	533	941	341			2000	158	403	524
B	366	296	284	297			1568	52	99	120
C	334	281	164	172			370	21	56	37
1	439	306			22	10	937	14	63	73
2	188	252			4	4	49	26	48	75
3	172	194			7	2	161	32	93	44
4	121	131			10	<1	55	42	13	12
5	200	129			18	2	43	36	12	19
6	160	136	79	90			<1	28	30	25
7	104	137			23	<1	3	9	11	31
8	127	102			9	<1	2	12	20	6
9	169	112			5	7	113	16	33	22
10	216	210			7	3	7	46	76	62
11	236	234			3	<1	14	21	80	62
12	201	162			1	2	9	33	76	51
13	229	145			4	2	7	18	98	36
14	236	225			<1	4	2	16	55	27
15	243	222			3	<1	17	12	79	47
16	232	219			2	<1	19	77	135	47
17	295	233			10	61	49	125	126	65
18	225	192			34	2	59	99	153	81
19	178	282			67	10	45	61	76	36
20	353	306			78	73	106	142	82	117
21	303	641			>100	>100	727	1140	753	119

	Winter October-April					Summer May-September				
BASE	Mean	std	se	High	Low	Mean	std	se	High	Low
A	604	321	86	689	518	689	636	259	948	430
B	350	167	45	395	306	378	544	222	600	156
C	232	126	34	266	198	132	124	50	183	82
1	268	157	44	312	224	165	345	141	306	24
2	199	111	31	230	168	15	17	7	22	8
3	135	67	19	154	115	44	60	27	70	17
4	88	54	15	104	73	43	47	19	62	24
5	110	60	16	126	94	17	17	7	24	11
6	107	61	16	123	91	36	36	15	51	21
7	92	56	16	108	77	9	8	3	12	5
8	83	55	15	98	69	5	4	2	6	3
9	79	47	13	91	66	25	40	16	41	9
10	96	61	16	113	80	12	16	6	18	5
11	108	76	20	128	88	11	7	3	14	8
12	90	56	15	105	75	9	11	5	14	4
13	102	62	17	119	86	6	5	2	9	4
14	118	64	17	135	100	5	5	2	7	3
15	127	59	16	143	111	9	6	2	12	7
16	147	60	16	163	131	21	26	11	32	11
17	167	66	18	185	149	48	39	16	63	32
18	181	60	16	197	165	43	31	13	56	31
19	231	139	40	271	191	65	34	14	79	51
20	277	143	41	319	236	191	130	53	244	137
21	640	436	126	766	514	429	383	157	586	272

Table 6 : NO_2-N concentrations (μgl^{-1})

1990 BASE	DECEMBER OUT	RETN
A	15.6	
B	16.9	
C	12.3	
1	11.9	
2	11.9	
3	11.4	
4	7.7	
5	9.6	6.4
6	11.0	5.5
7	8.7	3.5
8	23.8	25.1
9	21.1	24.1
10	18.8	19.5
11	2.5	4.2
12	2.2	2.3
13	<0.7	<0.7
14	<0.7	<0.7
15	<0.7	<0.7
16	<0.7	<0.7
17	<0.7	<0.7
18	<0.7	<0.7
19		
20		
21		

1991 BASE	JANUARY OUT	RETN	FEBRUARY	OUT	RETN	APRIL OUT	RETN	JULY OUT	RETN	OCTOBER OUT	RETN
A	9.8	16.5	12.9	14.8	15.5	11.1	5.3	14.5	13.9	21.9	17.1
B	14.0	8.9	6.3	7.4	3.9	8.9	2.1	2.4	4.6	14.1	9.0
C	7.4	5.4	6.3	4.7	3.6	2.4	2.5	2.9	0.9	7.9	7.3
1	8.1	3.3		2.5	3.2	2.1	1.6	<0.5	1.5	3.8	1.7
2	6.0	3.0		1.7	1.5	1.3	1.4	0.7	0.8	4.7	2.0
3	3.1	2.4		1.7	1.0	1.2		1.0		5.1	1.4
4	1.1	6.6		2.9	1.1	1.0	0.5	0.6	1.7	5.4	
5	3.4	6.1		3.5	1.6	1.5	0.9	<0.5	1.3	5.7	2.4
6	6.9	12.0		3.8	2.3	0.8	0.6	<0.5	2.2	5.3	1.6
7	9.8	11.0		1.2	0.9	<0.5	<0.5	<0.5	0.7		1.7
8	11.0	14.0		1.5	3.0	<0.5	<0.5	<0.5	<0.5	1.2	<0.5
9	15.0	7.2		2.6	1.3	<0.5	<0.5	<0.5	0.6	1.2	<0.5
10	2.7	2.8		2.3	2.1	<0.5	<0.5	<0.5	<0.5	0.7	<0.5
11	4.6	1.5		2.2	0.6	<0.5	<0.5	<0.5	3.1	2.1	1.1
12	<0.7	3.1		1.4	0.9	<0.5	<0.5	1.6	<0.5	0.7	<0.5
13	2.6	3.2		2.5	1.0	<0.5	0.9	<0.5	<0.5	2.1	<0.5
14	1.0	1.6		1.9	1.4	<0.5	0.8	<0.5	<0.5	0.7	11.1
15	1.3	0.7		1.5	2.0	<0.5	1.1	0.8	2.1	0.7	11.0
16	2.0	2.4		1.8	1.0	<0.5	1.0	1.0	1.5	7.9	4.3
17	2.6	1.9		1.9	0.9	0.7	0.8	1.0	1.1	7.8	6.4
18	2.0	1.9		2.2	1.6	0.9	1.1	1.1	2.0	2.1	1.3
19	2.1	1.9		2.2	1.3	1.3	1.4	1.7	5.1	<0.5	1.6
20	2.3	1.7		1.7	1.2	0.9	1.7	6.1	5.5	<0.5	<0.5
21	5.8	3.0		5.2	3.3	1.3	1.8	3.9	3.5	<0.5	0.9

Table 6 cont. : NO_2-N concentrations ($\mu g l^{-1}$)

1992 BASE	FEBRUARY OUT	FEBRUARY RETN	MAY OUT	MAY RETN	JUNE OUT	JUNE RETN	JULY OUT	JULY RETN	OCTOBER OUT	OCTOBER RETN
A	14.6	17.2	9.1	8.1			16.3	11.0	10.0	42.0
B	10.9	10.2	7.0	7.4			11.9	3.6	12.4	10.0
C	10.9	8.7	4.0	4.4			5.1	3.2	7.1	5.8
1	4.6	6.3			0.9	1.4	3.5	1.8	9.5	6.7
2	4.1	5.6			0.4	0.9	2.4	1.4	6.7	7.7
3	3.3	3.8			0.8	1.3	1.2	1.8	7.0	7.1
4	2.5	3.0			1.3	1.2	2.2	2.1	4.4	3.9
5	8.4	3.7			0.7	0.9	1.7	1.8	3.4	4.3
6	6.7	5.0	2.6	2.9			0.7	1.3	13.9	6.0
7	3.2	8.3			1.8	1.0	0.9	1.0	4.8	6.1
8	15.4	2.0			0.5	1.3	1.0	1.2	5.4	4.6
9	20.0	2.2			1.4	0.7	1.0	1.4	7.4	7.9
10	12.0	8.8			1.5	0.7	1.4	1.6	11.8	12.6
11	3.8	7.3			1.5	0.9	3.5	1.6	12.9	19.0
12	2.4	1.5			2.4	0.2	1.9	1.0	15.5	27.0
13	3.6	1.7			1.7	1.0	1.0	1.2	14.9	24.0
14	3.0	3.9			1.9	0.9	1.2	2.7	16.0	12.6
15	2.6	3.4			1.5	0.9	2.5	1.8	10.2	15.6
16	2.3	3.0			1.1	1.1	3.7	4.9	11.9	13.7
17	2.6	5.1			0.9	1.2	4.7		11.2	12.4
18	5.4	3.1			2.9	1.6	3.9		9.9	10.0
19	3.2	4.3			1.2	1.7	3.0		6.3	
20	3.6	5.9			3.0	2.7	6.2		53.0	
21	3.7	4.7			5.1	5.0	13.3		40.0	11.0

BASE	WINTER Mean	WINTER std	WINTER se	WINTER High	WINTER Low	SUMMER Mean	SUMMER std	SUMMER se	SUMMER High	SUMMER Low
A	16.0	8.2	2.2	18.2	13.8	12.2	3.0	1.2	13.4	10.9
B	9.6	3.9	1.0	10.7	8.6	6.1	3.1	1.3	7.4	4.9
C	6.6	2.8	0.7	7.3	5.9	3.4	1.4	0.6	4.0	2.9
1	5.0	3.1	0.9	5.9	4.2	1.6	1.0	0.4	2.0	1.1
2	4.4	3.0	0.8	5.3	3.6	1.1	0.7	0.3	1.4	0.8
3	4.0	3.0	0.9	4.9	3.2	1.2	0.3	0.2	1.4	1.1
4	3.3	2.2	0.6	4.0	2.7	1.5	0.6	0.2	1.7	1.3
5	4.4	2.5	0.7	5.0	3.7	1.1	0.5	0.2	1.3	0.9
6	5.8	4.0	1.1	6.9	4.7	1.7	1.0	0.4	2.1	1.3
7	4.6	3.7	1.0	5.6	3.6	0.9	0.5	0.2	1.1	0.7
8	7.7	8.4	2.2	9.9	5.4	0.8	0.4	0.2	0.9	0.6
9	7.9	8.3	2.2	10.1	5.7	0.9	0.4	0.2	1.1	0.7
10	6.8	6.7	1.8	8.6	5.0	1.0	0.6	0.2	1.2	0.7
11	4.5	5.2	1.4	5.8	3.1	1.8	1.2	0.5	2.3	1.3
12	4.1	7.4	2.0	6.1	2.2	1.2	0.8	0.3	1.6	0.9
13	4.1	6.6	1.8	5.9	2.4	0.9	0.5	0.2	1.1	0.7
14	3.9	5.1	1.3	5.3	2.6	1.2	0.9	0.4	1.6	0.8
15	3.6	4.7	1.3	4.9	2.4	1.6	0.6	0.3	1.8	1.3
16	3.7	4.2	1.1	4.9	2.6	2.2	1.5	0.6	2.8	1.6
17	3.9	3.9	1.0	5.0	2.9	1.8	1.5	0.7	2.4	1.1
18	3.0	3.1	0.8	3.8	2.2	2.3	1.0	0.4	2.7	1.9
19	2.4	1.6	0.5	2.8	1.9	2.5	1.4	0.6	3.2	1.9
20	6.6	14.8	4.5	11.0	2.1	4.7	1.5	0.7	5.4	4.0
21	6.7	10.4	3.0	9.7	3.7	6.2	3.6	1.6	7.8	4.5

Table 7 : PO_4-P concentrations (μgl^{-1})

1990 BASE	DECEMBER OUT	RETN
A	81.0	
B	57.0	
C	26.0	
1	31.0	
2	27.0	
3	19.0	
4	17.0	
5	17.0	
6	19.0	16.0
7	19.0	24.0
8	22.0	19.0
9	27.0	19.0
10	21.0	20.0
11	42.0	33.0
12	32.0	24.0
13	39.0	27.0
14	30.0	57.0
15	34.0	23.0
16	57.0	39.0
17	40.0	48.0
18	30.0	28.0
19		
20		
21		

1991 BASE	JANUARY OUT	RETN	FEBRUARY OUT		RETN	APRIL OUT	RETN	JULY OUT	RETN	OCTOBER OUT	RETN
A	57.0	121.0	85.0	3.8	32.0	117.0	52.4	24.5	46.7	88.2	64.7
B	44.0	42.0	3.1	3.9	134.0	43.2	23.6	2.5	7.5	61.1	38.3
C	23.0	28.0	30.0	15.7	34.5	18.4	20.1	1.1	1.9	34.8	32.5
1	17.0	27.0		2.7	36.8	23.9	21.9	1.1	1.4	16.0	18.3
2	15.0	23.0		2.9	145.0	26.0	18.2	<0.8	1.5	20.5	22.1
3	19.0	20.0		9.8	34.7	20.3		3.3		22.3	15.6
4	17.0	21.0		2.9	30.0	5.1	7.6	3.5	1.5	22.4	
5	23.0	21.0		11.8	21.3	6.2	13.9	<0.8	4.6	18.4	17.9
6	20.0	20.0		4.4	20.1	5.9	6.6	<0.8	1.6	17.7	26.3
7	27.0	24.0		2.5	19.2	5.7	6.5	4.2	1.7		23.1
8	20.0	17.0		8.8	23.7	5.2	5.6	3.4	5.2	12.7	11.4
9	17.0	22.0		4.8	18.3	5.2	6.3	3.3	1.7	14.1	12.5
10	19.0	19.0		13.5	18.5	5.0	10.4	3.2	2.4	12.2	11.4
11	22.0	15.0		1.7	13.1	5.6	9.6	3.6	6.3	16.7	20.6
12	15.0	17.0		16.9	15.4	6.7	5.8	6.4	4.3	11.8	11.6
13	20.0	19.0		14.7	8.1	16.0	11.1	<0.8	3.6	14.5	11.3
14	15.0	18.0		1.7	15.3	16.2	14.9	0.9	3.9	27.0	38.6
15	15.0	26.0		1.3	9.7	18.9	18.5	5.3	4.2	49.3	45.9
16	23.0	30.0		18.3	13.7	18.5	18.6	15.1	5.4	40.0	43.8
17	27.0	43.0		20.7	12.2	21.6	14.1	5.3	5.6	86.0	49.9
18	45.0	52.0		62.2	5.7	29.7	24.5	10.5	7.9	43.6	93.8
19	59.0	50.0		141.0	19.3	38.3	21.4	22.2	31.6	41.5	99.0
20		79.0		136.2	1.9	30.9	23.6	70.5	76.4	57.1	67.9
21	30.0	21.0		56.1	21.2	166.0	18.9	56.7	50.1	77.4	82.0

Table 7 cont. : PO_4-P concentrations (μgl^{-1})

1992 BASE	FEBRUARY OUT	FEBRUARY RETN	MAY OUT	MAY RETN	JUNE OUT	JUNE RETN	JULY OUT	JULY RETN	OCTOBER OUT	OCTOBER RETN
A	64.0	80.0	41.0	30.0			69.0	33.0	33.0	79.0
B	39.0	45.0	23.0	22.0			48.0	10.0	28.0	24.0
C	40.0	32.0	10.0	11.0			43.0	9.0	23.0	17.0
1	22.0	32.0			25.0	8.0	14.0	5.0	23.0	19.0
2	24.0	26.0			16.0	19.0	13.0	4.0	25.0	23.0
3	21.0	19.0			12.0	7.0	9.0	<1.0	32.0	16.0
4	19.0	20.0			8.0	6.0	8.0	5.0	11.0	10.0
5	20.0	16.0			21.0	4.0	15.0	3.0	8.0	10.0
6	21.0	18.0	7.0	8.0			16.0	4.0	3.7	10.0
7	16.0	17.0			12.0	3.0	7.0	2.0	9.0	16.0
8	19.0	13.0			7.0	3.0	7.0	3.0	13.0	10.0
9	24.0	14.0			6.0	3.0	3.0	2.0	22.0	15.0
10	31.0	29.0			5.0	9.0	1.0	2.0	35.0	30.0
11	33.0	34.0			4.0	3.0	1.0	<1.0	37.0	25.0
12	27.0	22.0			3.0	4.0	<1.0	2.0	31.0	31.0
13	32.0	19.0			3.0	4.0	<1.0	12.0	38.0	21.0
14	36.0	35.0			3.0	8.0	1.0	17.0	25.0	23.0
15	35.0	33.0			5.0	7.0	2.0	7.0	35.0	64.0
16	33.0	37.0			8.0	8.0	1.0	18.0	49.0	41.0
17	46.0	40.0			10.0	10.0	52.0	18.0	43.0	43.0
18	89.0	29.0			22.0	4.0	25.0	42.0	56.0	49.0
19	25.0	57.0			17.0	10.0	21.0	35.0	30.0	27.0
20	74.0	74.0			34.0	36.0	67.0	36.0	44.0	39.0
21	70.0	149.0			93.0	72.0	84.0	87.0	167.0	105.0

BASE	Winter October-April Mean	std	se	high	low	Summer May-September Mean	std	se	high	low
A	68.4	30.9	8.3	76.7	60.2	40.7	14.6	5.9	46.6	34.8
B	41.9	30.4	8.1	50.0	33.8	18.8	15.0	6.1	25.0	12.7
C	26.8	7.2	1.9	28.7	24.9	12.7	14.1	5.8	18.4	6.9
1	22.4	8.2	2.3	24.6	20.1	9.1	8.4	3.4	12.5	5.7
2	30.6	33.6	9.3	39.9	21.3	9.0	7.2	3.0	12.0	6.1
3	20.7	6.5	1.9	22.6	18.9	6.4	4.1	1.8	8.2	4.5
4	15.3	7.7	2.2	17.5	13.0	5.3	2.4	1.0	6.3	4.4
5	14.7	6.2	1.6	16.4	13.1	8.0	7.4	3.0	11.0	5.0
6	14.9	7.0	1.9	16.8	13.0	6.2	5.2	2.1	8.3	4.1
7	16.1	7.6	2.1	18.2	14.0	5.0	3.6	1.5	6.4	3.5
8	14.3	5.7	1.5	15.8	12.8	4.8	1.7	0.7	5.5	4.1
9	15.8	6.7	1.8	17.6	14.0	3.2	1.4	0.6	3.7	2.6
10	19.6	8.6	2.3	21.9	17.4	3.8	2.6	1.1	4.9	2.7
11	22.0	12.0	3.2	25.2	18.8	3.1	1.9	0.8	3.9	2.3
12	19.1	8.6	2.3	21.4	16.8	3.4	1.8	0.8	4.1	2.6
13	20.8	9.4	2.5	23.3	18.2	3.9	3.9	1.6	5.5	2.3
14	25.2	13.2	3.5	28.7	21.7	5.6	5.6	2.3	7.9	3.3
15	29.2	16.1	4.3	33.5	24.9	5.1	1.7	0.7	5.8	4.4
16	33.0	12.6	3.4	36.4	29.6	9.3	5.7	2.3	11.6	6.9
17	38.2	18.2	4.9	43.0	33.3	16.8	16.3	6.6	23.5	10.2
18	45.5	23.6	6.3	51.8	39.2	18.6	12.9	5.3	23.8	13.3
19	50.7	34.6	10.0	60.7	40.7	22.8	8.4	3.4	26.2	19.4
20	52.4	36.1	10.4	62.8	42.0	53.3	18.2	7.4	60.7	45.9
21	80.3	53.4	15.4	95.7	64.9	73.8	15.8	6.5	80.3	67.3

Table 8 : SiO_2-Si concentrations (μgl^{-1})

1990 BASE	DECEMBER OUT	RETN
A	325.0	
B	250.0	
C	100.0	
1	167.0	
2	167.0	
3	63.0	
4	50.0	
5	50.0	50.0
6	50.0	84.0
7	50.0	50.0
8	98.0	84.0
9	114.0	84.0
10	108.0	100.0
11	167.0	117.0
12	100.0	100.0
13	117.0	100.0
14	117.0	117.0
15	100.0	84.0
16	167.0	167.0
17	117.0	167.0
18	100.0	99.0
19		
20		
21		

1991 BASE	JANUARY OUT	RETN	FEBRUARY	OUT	RETN	APRIL OUT	RETN	JULY OUT	RETN	OCTOBER OUT	RETN
A	513.0	1170.0	780.0	792.0	840.0	438.0	176.0	211.0	190.0	525.0	451.0
B	507.0	417.0	284.0	409.0	295.0	201.0	68.4	11.2	11.9	361.0	157.0
C	262.0	223.0	291.0	237.0	258.0	85.1	79.4	15.2	11.7	108.0	115.0
1	215.0	217.0		220.0	341.0	87.5	52.9	8.2	9.4	3.3	5.5
2	202.0	190.0		179.0	200.0	84.7	63.3	2.4	20.4	22.5	29.6
3	161.0	145.0		138.0	167.0	71.6		2.2		2.6	<1.7
4	70.0	149.0		108.0	140.0	41.3	34.2	3.6	5.6	<1.7	
5	154.0	170.0		115.0	108.0	39.3	38.8	1.8	5.1	<1.7	<1.7
6	153.0	117.0		119.0	157.0	31.1	42.5	3.1	5.3	<1.7	<1.7
7	197.0	131.0		81.3	94.2	44.2	58.5	10.5	7.7		5.8
8	121.0	127.0		82.8	78.0	43.4	32.7	16.0	12.7	<1.7	<1.7
9	94.0	117.0		86.4	75.4	33.3	32.7	12.8	7.3	<1.7	<1.7
10	100.0	89.0		113.0	107.0	27.3	30.5	18.8	13.5	<1.7	<1.7
11	149.0	81.0		94.8	70.2	23.7	32.3	16.3	20.5	<1.7	3.2
12	73.0	115.0		79.8	103.0	27.3	21.3	10.7	10.7	<1.7	<1.7
13	118.0	127.0		116.0	62.6	40.7	42.0	21.1	13.3	<1.7	<1.7
14	79.0	102.0		97.3	99.2	33.8	44.1	23.6	16.7	14.3	78.3
15	87.0	74.0		71.7	70.0	35.5	48.4	19.6	32.7	48.3	49.8
16	138.0	136.0		98.1	101.0	30.0	30.6	16.7	21.6	4.4	49.4
17	140.0	173.0		84.4	106.0	17.7	22.7	12.8	19.3	102.0	68.9
18	155.0	180.0		164.0	75.6	25.1	14.2	6.4	18.4	45.6	135.0
19	202.0	188.0		262.0	99.3	37.4	35.9	5.9	9.2	50.9	117.0
20	313.0	225.0		298.0	215.0	14.0	29.6	6.0	8.9	66.5	72.4
21	740.0	447.0		594.0	409.0	42.8	43.6	7.7	12.9	99.8	99.0

Table 8 cont. : SiO_2-Si concentrations (μgl^{-1})

1992 BASE	FEBRUARY OUT	FEBRUARY RETN	MAY OUT	MAY RETN	JUNE OUT	JUNE RETN	JULY OUT	JULY RETN	OCTOBER OUT	OCTOBER RETN
A	504.0	530.0	174.0	162.0			422.0	223.0	432.0	561.0
B	304.0	319.0	121.0	122.0			303.0	53.0	175.0	171.0
C	334.0	255.0	41.0	46.0			142.0	57.0	123.0	84.0
1	217.0	268.0			47.0	20.0	76.0	52.0	114.0	113.0
2	199.0	211.0			23.0	23.0	56.0	52.0	89.0	120.0
3	162.0	167.0			19.0	18.0	55.0	47.0	157.0	76.0
4	122.0	119.0			10.0	19.0	34.0	37.0	60.0	44.0
5	140.0	117.0			15.0	12.0	41.0	37.0	39.0	43.0
6	131.0	126.0	11.0	13.0			14.0	46.0		49.0
7	103.0	131.0			37.0	10.0	63.0	36.0	32.0	59.0
8	120.0	102.0			16.0	22.0	70.0	49.0	39.0	21.0
9	157.0	108.0			14.0	20.0	42.0	31.0	124.0	51.0
10	188.0	138.0			28.0	10.0	25.0	29.0	131.0	122.0
11	189.0	180.0			20.0	30.0	79.0	56.0	117.0	86.0
12	161.0	110.0			14.0	13.0	62.0	41.0	112.0	98.0
13	190.0	109.0			4.0	9.0	66.0	99.0	137.0	90.0
14	196.0	193.0			15.0	5.0	90.0	155.0	99.0	93.0
15	194.0	191.0			16.0	35.0	122.0	78.0	114.0	111.0
16	190.0	188.0				8.0	126.0	140.0	118.0	125.0
17	215.0	197.0			9.0	20.0	106.0	92.0	134.0	107.0
18	187.0	164.0			25.0	8.0	59.0	62.0	134.0	140.0
19	157.0	225.0			22.0	23.0	60.0	55.0	110.0	98.0
20	272.0	267.0			16.0	26.0	27.0	196.0	152.0	143.0
21	260.0	400.0			15.0	21.0	83.0	270.0	196.0	267.0

BASE	Winter October-April Mean	std	se	high	low	Summer May-September Mean	std	se	high	low
A	574.1	239.5	64.0	638.1	510.1	230.3	88.2	36.0	266.3	194.3
B	279.9	115.2	30.8	310.7	249.1	103.7	99.9	40.8	144.5	62.9
C	182.5	87.4	23.4	205.8	159.1	52.2	43.3	17.7	69.8	34.5
1	155.5	98.8	27.4	182.9	128.1	35.4	24.9	10.2	45.6	25.3
2	135.2	67.0	18.6	153.7	116.6	29.5	18.8	7.7	37.1	21.8
3	109.3	60.8	17.5	126.8	91.7	28.2	19.7	8.8	37.0	19.4
4	78.2	45.6	13.2	91.4	65.0	18.2	13.2	5.4	23.6	12.8
5	76.1	54.2	14.5	90.6	61.7	18.6	15.1	6.2	24.8	12.5
6	81.6	53.4	14.8	96.4	66.8	15.4	14.2	5.8	21.2	9.6
7	79.8	49.2	13.6	93.4	66.1	27.4	20.0	8.2	35.6	19.2
8	67.9	42.7	11.4	79.3	56.5	31.0	21.3	8.7	39.6	22.3
9	77.0	45.6	12.2	89.2	64.9	21.2	11.9	4.8	26.0	16.3
10	89.7	53.0	14.2	103.8	75.5	20.7	7.2	2.9	23.7	17.8
11	93.7	61.1	16.3	110.0	77.3	37.0	23.0	9.4	46.3	27.6
12	78.7	46.4	12.4	91.1	66.3	25.2	19.6	8.0	33.2	17.2
13	89.4	51.8	13.8	103.2	75.5	35.4	35.0	14.3	49.7	21.1
14	97.4	49.4	13.2	110.6	84.2	50.9	54.3	22.2	73.0	28.7
15	91.3	47.2	12.6	104.0	78.7	50.6	37.8	15.4	66.0	35.1
16	110.2	58.8	15.7	125.9	94.5	62.5	57.9	25.9	88.4	36.6
17	118.0	56.7	15.2	133.1	102.8	43.2	39.9	16.3	59.5	26.9
18	115.6	55.0	14.7	130.3	100.9	29.8	22.6	9.2	39.0	20.6
19	131.9	71.8	20.7	152.6	111.1	29.2	21.0	8.6	37.8	20.6
20	172.3	102.9	29.7	202.0	142.6	46.6	67.3	27.5	74.1	19.2
21	299.9	214.0	61.8	361.6	238.1	68.3	93.7	38.3	106.5	30.0

Table 9 : Suspended solids concentrations (mgl^{-1})

1990 BASE	DECEMBER OUT	RETN
A	7.0	
B	6.0	
C	10.0	
1	<3.0	
2	20.0	
3	14.0	
4	5.0	<3.0
5	<3.0	<3.0
6	8.0	<3.0
7	<3.0	3.0
8	4.0	6.0
9	<3.0	11.0
10	4.0	<3.0
11	11.0	10.0
12	<3.0	9.0
13	15.0	15.0
14	40.0	10.0
15	33.0	6.0
16	47.0	38.0
17	48.0	60.0
18	40.0	50.0
19		
20		
21		

1991 BASE	JANUARY OUT	RETN	FEBRUARY OUT	RETN	APRIL OUT	RETN	JULY OUT	RETN	OCTOBER OUT	RETN
A	5.0	15.0	6.0	21.0	<3.0	4.0	22.0	<5.0	<5.0	53.0*	44.5*
B	7.0	25.0	17.0	18.0	<3.0	<3.0	26.0	<5.0	<5.0	58.0*	68.0*
C	30.0	29.0	20.0	26.0	<3.0	8.0	19.0	<5.0	7.0	54.5*	64.5*
1	17.0	<3.0		19.0	<3.0	7.0	10.0	<5.0	<5.0	34.5*	32.0*
2	32.0	<3.0		6.0	<3.0	4.0	17.0	<5.0	<5.0	41.5*	16.0*
3	14.0	21.0		25.0	17.0	6.0		<5.0		28.0*	18.8*
4	58.0	4.0		12.0	<3.0	<3.0	<3.0	<5.0	<5.0	30.0*	40.0*
5	4.0	<3.0		12.0	6.0	23.0	8.0	<5.0	<5.0	40.0*	33.5*
6	20.0	3.0		7.0	22.0	<3.0	6.0	<5.0	<5.0	23.5*	48.0*
7	<3.0	7.0		<3.0	4.0	<3.0	<3.0	<5.0	<5.0	36.0*	21.5*
8	6.0	9.0		<3.0	16.0	7.0	<3.0	<5.0	<5.0	41.0*	47.0*
9	6.0	7.0		11.0	<3.0	<3.0	<3.0	<5.0	149.0	73.0*	35.5*
10	39.0	<3.0		5.0	6.0	<3.0	<3.0	<5.0	149.0	41.5*	37.0*
11	4.0	5.0		6.0	4.0	11.0	<3.0	<5.0	35.0	24.0*	35.5*
12	<3.0	8.0		<3.0	<3.0	7.0	<3.0	<5.0	<5.0	52.5*	33.0*
13	5.0	<3.0		9.0	<3.0	6.0	<3.0	<5.0	129.0	41.0*	42.0*
14	24.0	5.0		3.0	<3.0	4.0	<3.0	<5.0	<5.0	31.0*	20.0*
15	7.0	17.0		8.0	<3.0	6.0	7.0	<5.0	<5.0	35.5*	27.5*
16	8.0	12.0		4.0	5.0	11.0	16.0	<5.0	<5.0	51.0*	58.0*
17	11.0	14.0		8.0	16.0	<3.0	5.0	<5.0	<5.0	89.0*	61.5*
18	16.0	38.0		19.0	45.0	40.0	4.0	<5.0	40.0	77.5*	85.5*
19	29.0	32.0		23.0	6.0	40.0	29.0	<5.0	<5.0	66.5*	94.5*
20	30.0	44.0		17.0	35.0	35.0	27.0	<5.0	127.0	56.0*	72.5*
21	16.0	17.0		15.0	18.0	56.0	18.0	<5.0	<5.0	49.0*	61.0*

* None-saline method believed to have been used

Table 9 cont. : Suspended solids concentrations (mgl^{-1})

1992 BASE	FEBRUARY OUT	FEBRUARY RETN	MAY OUT	MAY RETN	JUNE OUT	JUNE RETN	JULY OUT	JULY RETN	OCTOBER OUT	OCTOBER RETN
A	41.0*	48.0*	16.0	17.0			3.0	5.0	10.0	3.0
B	43.0*	34.0*	15.0	13.0			4.0	4.0	12.0	5.0
C	52.0*	44.0*					5.0	5.0	3.0	3.0
1	41.0*	37.0*			<2.0	<2.0	<2.0		6.0	2.0
2	30.0*	45.0*			<2.0	<2.0	2.0		10.0	4.0
3	32.0*	51.0*			<2.0	<2.0	3.0		8.0	4.0
4	33.0*	37.0*			3.0	7.0	5.0	<2.0	3.0	4.0
5	27.0*	35.0*			<2.0	<2.0	2.0	2.0	3.0	3.0
6	33.0*	43.0*					<2.0	<2.0	22.0	3.0
7	28.0*	28.0*			<2.0	<2.0	<2.0	<2.0	3.0	3.0
8	36.0*	25.0*			<2.0	<2.0	3.0	2.0	3.0	3.0
9	37.0*	37.0*			3.0	2.0	<2.0	<2.0	12.0	3.0
10	39.0*	38.0*			<2.0	<2.0	2.0	<2.0	10.0	3.0
11	53.0*	41.0*			<2.0	26.0	<2.0	<2.0	14.0	4.0
12	48.0*	43.0*			<2.0	<2.0	<2.0	<2.0	13.0	4.0
13	48.0*	29.0*			<2.0	8.0	<2.0	<2.0	13.0	3.0
14	38.0*	39.0*			2.0	3.0	<2.0	2.0	25.0	3.0
15	37.0*	40.0*			2.0	3.0	2.0	4.0	28.0	8.0
16	56.0*	50.0*			<2.0	3.0	7.0	<2.0	25.0	8.0
17	69.0*	66.0*			<2.0	2.0	4.0	4.0	27.0	20.0
18	28.0*	55.0*			42.0	6.0	17.0	10.0	86.0	25.0
19	72.0*	63.0*			9.0	4.0	8.0	15.0	37.0	5.0
20	62.0*	89.0*			4.0	4.0	15.0	7.0	52.0	15.0
21	66.0*	59.0*			8.0	13.0	12.0	7.0	70.0	6.0

* Non-saline method believed to have been used

BASE	Winter October-April Mean	std	se	high	low	Summer May-September Mean	std	se	high	low
A	9.5	7.0	2.2	11.7	7.2	7.7	6.3	2.6	10.2	5.1
B	11.9	8.7	2.8	14.7	9.1	6.8	5.1	2.1	8.9	4.7
C	15.0	10.6	3.4	18.3	11.6	4.9	1.6	0.8	5.7	4.1
1	7.3	6.4	2.1	9.4	5.1	1.4	0.9	0.4	1.8	1.0
2	10.7	9.8	3.3	13.9	7.4	1.8	0.7	0.3	2.1	1.5
3	13.6	6.9	2.4	16.1	11.2	1.9	0.9	0.4	2.3	1.4
4	9.2	16.5	5.2	14.4	4.0	3.5	2.0	0.8	4.3	2.7
5	6.4	6.4	2.0	8.4	4.3	1.8	0.8	0.3	2.1	1.4
6	9.4	8.1	2.6	12.0	6.8	1.8	0.8	0.4	2.1	1.4
7	2.8	1.7	0.5	3.3	2.2	1.3	0.8	0.3	1.7	1.0
8	5.7	4.1	1.3	7.0	4.4	1.8	1.0	0.4	2.2	1.4
9	5.6	4.2	1.3	6.9	4.3	26.4	54.8	22.4	48.8	4.0
10	7.3	10.9	3.4	10.7	3.9	26.1	55.0	22.4	48.5	3.6
11	7.1	3.9	1.2	8.3	5.8	11.1	14.0	5.7	16.8	5.4
12	4.9	3.9	1.2	6.1	3.6	1.5	0.7	0.3	1.8	1.2
13	7.1	5.3	1.7	8.7	5.4	23.8	47.1	19.2	43.0	4.5
14	11.7	12.6	4.0	15.7	7.7	2.2	0.6	0.3	2.4	1.9
15	12.2	9.9	3.1	15.3	9.0	2.7	0.7	0.3	2.9	2.4
16	17.4	13.9	4.4	21.8	13.0	2.8	2.0	0.8	3.7	2.0
17	21.1	18.1	5.7	26.8	15.3	2.6	1.2	0.5	3.1	2.1
18	36.3	21.6	6.8	43.1	29.5	19.6	15.8	6.4	26.0	13.1
19	25.1	12.3	4.4	29.5	20.8	6.8	4.4	1.8	8.6	5.0
20	31.9	11.8	4.2	36.0	27.7	26.6	45.1	18.4	45.0	8.2
21	27.0	21.4	7.6	34.6	19.4	7.5	4.1	1.7	9.2	5.8

N.B. DOES NOT INCLUDE SUSPECT DATA

Table 10 : Chlorophyll A concentrations (μgl^{-1})

1991 BASE	APRIL OUT	APRIL RETN	JULY OUT	JULY RETN	OCTOBER OUT	OCTOBER RETN
A	1.2	3.9	13.3	8.5	1.8	0.8
B	1.5	2.4	8.7	2.1	1.8	1.6
C	1.7	3.1	10.0	3.5	0.9	1.0
1	2.2	2.9	1.8	1.4	0.9	0.7
2		1.8	1.9	2.9	1.3	0.8
3	0.8		1.6		0.8	1.7
4	1.2	4.7	1.3	1.3	1.1	2.4
5	3.2	4.2	1.7	1.7	1.7	1.1
6	2.9	5.8	2.2	1.7	0.5	0.8
7	1.5	1.1	0.3		1.4	0.7
8	1.0	1.6	0.4	0.6	1.8	1.2
9	3.8	1.8	0.5	0.9	1.3	1.9
10	2.1	4.1	1.8	1.8	0.9	1.5
11	3.9	3.3	1.0	2.1	1.3	1.9
12	4.1	4.7	1.7	2.4	1.7	1.7
13	2.4	5.3	3.3	3.4	1.9	2.5
14	1.2	1.9	2.0	2.1	1.5	1.9
15		2.6	1.9	2.2	2.2	2.0
16	1.9	2.1	1.6	1.4	2.3	1.7
17	3.0	1.7	1.7	1.7	0.7	2.7
18	7.8	4.9	2.8	2.0	2.7	2.5
19	12.0	6.3	2.5	2.5	2.2	4.2
20	7.2	7.7	6.9	4.8	3.0	3.1
21	14.2	5.3	2.5	2.5	2.2	2.4

1992 BASE	FEBRUARY OUT	FEBRUARY RETN	MAY OUT	MAY RETN	JUNE OUT	JUNE RETN	JULY OUT	JULY RETN	OCTOBER OUT	OCTOBER RETN
A	0.9	1.3	1.8	1.6			2.3	8.8	1.7	1.1
B	1.3	0.8	2.6	3.0			2.9	4.7	1.5	1.2
C	1.0	0.8	2.5	3.3			2.3	0.6	1.5	1.2
1	1.0	1.1			2.5	1.3	3.4	2.4	1.1	2.1
2	0.9	0.9			1.3	1.0	2.0	2.5	1.3	1.0
3	0.6	0.9			1.0	0.9	2.0	1.3	1.0	0.5
4	0.6	0.5			2.0	1.6	2.8	2.4	0.3	1.5
5	0.8	0.8			1.4	1.3	3.1	1.7	1.5	1.0
6	1.2	1.0	1.7	1.3			2.4	3.3	1.2	1.4
7	1.2	0.8			1.2	1.4	1.9	1.4	3.8	1.3
8	0.8	1.0			1.3	1.8	1.7	0.6	1.7	0.6
9	1.3	0.9			2.6	2.1	2.1	1.7	3.8	4.6
10	1.0	0.5			3.3	2.9	3.4	1.4	2.6	2.1
11	0.9	0.5			3.4	4.5	1.8	1.7	1.7	1.7
12	1.2	0.6			4.1	4.6	4.9	1.7	1.7	1.1
13	1.2	0.6			5.6	9.8	2.1	1.3	1.8	1.6
14	0.6	0.6			7.6	8.4	2.5	3.7	1.8	0.8
15	1.4	0.9			6.5	3.3	2.1	3.1	1.3	1.2
16	1.6	1.6			3.6	3.7	1.2	2.3	3.0	1.3
17	2.0	2.0			3.7	3.8	2.4	3.2	2.3	1.5
18	2.4	1.9			2.7	2.9	1.9	3.8	3.3	1.6
19	1.7	1.6			1.8	1.4	3.6	3.8	2.3	1.1
20	1.6	3.0			1.5	1.9	6.0	3.8	3.0	2.5
21	1.4	1.6			3.1	2.9	4.4	6.2	6.0	1.6

Table 10 cont. : Chlorophyll A concentrations ($\mu g l^{-1}$)

BASE	Winter October-April Mean	std	se	high	low	Summer May-September Mean	std	se	high	low
A	1.6	0.9	0.3	1.9	1.2	6.0	4.4	1.8	7.8	4.2
B	1.5	0.4	0.2	1.7	1.3	4.0	2.2	0.9	4.9	3.1
C	1.4	0.7	0.3	1.7	1.2	3.7	3.0	1.2	4.9	2.5
1	1.5	0.7	0.3	1.7	1.2	2.1	0.8	0.3	2.4	1.8
2	1.1	0.3	0.1	1.3	1.0	1.9	0.7	0.3	2.2	1.7
3	0.9	0.3	0.1	1.0	0.8	1.3	0.4	0.2	1.5	1.1
4	1.5	1.3	0.5	2.0	1.1	1.9	0.6	0.2	2.1	1.7
5	1.8	1.2	0.4	2.2	1.4	1.8	0.6	0.2	2.1	1.6
6	1.8	1.6	0.6	2.4	1.3	2.1	0.6	0.3	2.4	1.8
7	1.5	0.9	0.3	1.8	1.1	1.2	0.5	0.2	1.5	1.0
8	1.2	0.4	0.1	1.3	1.0	1.1	0.5	0.2	1.3	0.8
9	2.4	1.3	0.5	2.9	2.0	1.7	0.7	0.3	2.0	1.3
10	1.9	1.1	0.4	2.2	1.5	2.4	0.8	0.3	2.7	2.1
11	1.9	1.1	0.4	2.3	1.5	2.4	1.2	0.5	2.9	1.9
12	2.1	1.4	0.5	2.6	1.6	3.2	1.3	0.5	3.8	2.7
13	2.2	1.3	0.5	2.6	1.7	4.3	2.8	1.1	5.4	3.1
14	1.3	0.5	0.2	1.5	1.1	4.4	2.6	1.1	5.5	3.3
15	1.7	0.6	0.2	1.9	1.5	3.2	1.5	0.6	3.8	2.6
16	1.9	0.5	0.2	2.1	1.8	2.3	1.0	0.4	2.7	1.9
17	2.0	0.7	0.2	2.2	1.7	2.7	0.9	0.4	3.1	2.4
18	3.4	1.9	0.7	4.1	2.7	2.7	0.6	0.3	2.9	2.4
19	3.9	3.4	1.2	5.1	2.7	2.6	0.9	0.4	3.0	2.2
20	3.9	2.1	0.7	4.6	3.1	4.1	2.0	0.8	5.0	3.3
21	4.4	4.1	1.4	5.8	2.9	3.6	1.3	0.5	4.1	3.0

BASE	Annual Mean	std	se	high	low
A	4.3	4.1	1.7	6.0	2.6
B	2.8	2.2	0.9	3.7	2.0
C	2.6	2.6	1.1	3.7	1.5
1	1.9	0.8	0.3	2.2	1.6
2	1.6	0.6	0.2	1.8	1.4
3	1.1	0.4	0.2	1.3	1.0
4	1.9	1.1	0.4	2.3	1.5
5	2.0	0.9	0.3	2.3	1.6
6	2.2	1.5	0.6	2.8	1.6
7	1.5	0.8	0.3	1.8	1.1
8	1.2	0.5	0.2	1.4	1.0
9	2.3	1.2	0.4	2.7	1.8
10	2.3	0.9	0.3	2.6	2.0
11	2.4	1.1	0.4	2.7	2.0
12	2.9	1.4	0.5	3.4	2.4
13	3.4	2.3	0.8	4.3	2.6
14	2.9	2.4	0.8	3.8	2.1
15	2.6	1.4	0.5	3.1	2.1
16	2.2	0.8	0.3	2.5	1.9
17	2.4	0.9	0.3	2.7	2.0
18	3.2	1.6	0.6	3.8	2.7
19	3.6	2.9	1.0	4.7	2.6
20	4.3	2.1	0.7	5.0	3.5
21	4.4	3.3	1.2	5.6	3.3

NRA

National Rivers Authority

Southern Region

Regional Office
Guildbourne House Chatsworth Road
Worthing West Sussex BN11 1LD
(0903) 820692